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PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES

TOPOGRAPHIC AND GEOLOGIC

ATLAS

of

PENNSYLVANIA

No. 54

BROOKVILLE QUADRANGLE

GEOLOGY AND MINERAL RESOURCES

By

C. K. GRAEBER and R. M. FOOSE

DEPARTMENT OF INTERNAL AFFAIRS
William S. Livengood, Jr., *Secretary*

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Geo. H. Ashley, *State Geologist*

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PREFACE

The field work for this report was done by Chas. K. Graeber of the Survey staff in the summers of 1931-1934. For a short time Marchant N. Shaffner of the Survey staff assisted in the field. Some of the data on gas wells and gas production was obtained by Herbert H. Hughes, formerly of the Survey staff.

Work on the report was discontinued in 1935 when Mr. Graeber left the Survey.

During the fall of 1940 and spring of 1941 Richard M. Foose spent some time in the area. This report has been prepared in its final form by Mr. Foose. Revisions were made in the original manuscript on the section of stratigraphy, and the chapter on mineral resources and the mineral resources map have been almost entirely prepared by Mr. Foose. Mr. Shaffner prepared the chapter on oil and gas and made the drawing for plate 16.

Grateful acknowledgment is made to the many persons in Jefferson County who aided the work on this report, both by practical help in the field and by offering valuable information from records.

GEOLOGY AND MINERAL RESOURCES OF THE BROOKVILLE QUADRANGLE, PENNSYLVANIA

By Chas. K. Graeber and Richard M. Foose

INTRODUCTION

Location

For the purpose of detailed topographic and geologic mapping, Pennsylvania has been divided into quadrangular areas bounded by 15 minute meridians of longitude and parallels of latitude and given the name of a prominent place in the area. Thus, the Brookville quadrangle embraces an area of 225.06 square miles in northwestern Pennsylvania that extends from parallels of latitude 41°00′ to 41°15′ and from meridians of longitude 79°00′ to 79°15′. It has a length from north to south of about 17½ miles and a width from east to west of about 13¼ miles. It is slightly narrower at the north owing to the convergence of the meridians toward the north pole.

The quadrangle is bounded on the north, east, south, and west by the Marienville, DuBois, Smicksburg, and Clarion quadrangles respectively. It lies mostly in Jefferson County (fig. 1), but includes on the west a 2-mile strip in Clarion and Armstrong Counties. Highway distances in miles from Brookville to surrounding boroughs and cities are as follows:

Clarion	17	Indiana	52	Punxsutawney	24
Clearfield	46	Kittanning	69	Ridgway	36
DuBois	21	Pittsburgh	97	Warren	89

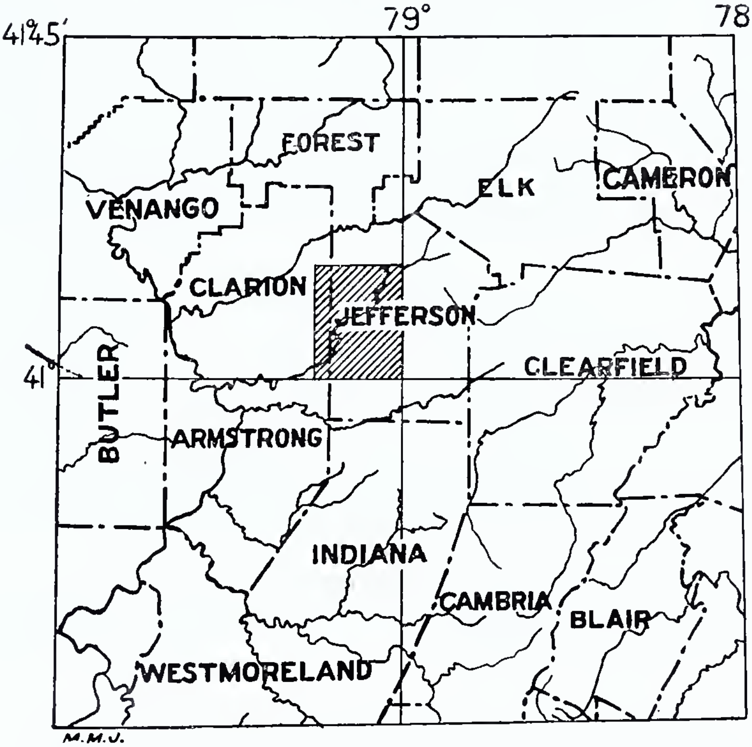

Figure 1. Sketch showing the location of the Brookville quadrangle.

Monthly and annual mean temperatures in degrees Fahrenheit, and precipitation in inches as recorded at Brookville are given in the tables below:

*Monthly and Annual Mean Temperatures**

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Departure from normal
1916	31.1	21.9	26.0	^{b}44.8	57.9	^{a}60.0	^{a}70.8	68.2	56.9	^{a}48.1	37.6	26.4	45.8	----
1917	22.8	20.0	34.5	43.8	49.2	61.7	68.0	^{a}66.4	55.4	^{a}42.8	33.2	17.0	42.9	----
1918	10.8	23.9	----	44.0	61.2	60.9	65.7	69.4	^{f}54.6	^{b}50.9	^{a}38.8	^{b}34.0	----	----
1919	28.0	27.7	^{a}36.6	44.8	54.4	68.6	^{b}69.2	^{a}64.0	60.4	^{c}53.0	^{b}37.4	^{c}21.2	47.2	----
1920	^{a}15.4	^{b}20.5	^{d}34.4	^{b}40.2	52.8	62.8	64.8	^{b}65.8	60.0	^{a}53.2	^{a}36.2	^{a}29.5	47.1	----
1921	^{c}26.8	^{c}29.4	^{a}43.3	50.4	^{a}56.4	^{a}65.7	71.7	63.8	65.3	^{b}49.0	39.2	28.4	49.1	----
1922	21.6	28.8	35.8	^{a}46.8	57.9	64.6	67.8	64.4	^{a}62.4	50.3	39.2	27.4	47.2	+0.6
1923	26.0	21.3	32.0	^{a}43.2	^{a}53.0	^{a}66.1	66.6	64.3	60.6	45.2	36.0	35.8	45.8	—0.7
1924	22.0	20.6	^{a}33.0	42.2	----	61.0	^{a}64.5	65.2	55.2	47.8	34.6	25.0	----	----
1925	18.4	^{a}31.0	^{b}35.5	^{b}47.0	50.0	65.8	^{a}65.1	^{b}65.6	63.0	41.6	^{b}34.7	----	----	----
1926	22.0	^{b}23.6	28.2	^{b}40.0	^{a}53.9	58.9	66.0	68.0	^{b}60.7	^{a}47.7	^{b}35.2	21.6	43.8	—2.7
1927	^{a}23.2	^{b}31.2	^{b}37.6	43.0	^{b}53.9	^{a}58.2	^{b}67.0	^{b}60.7	^{b}60.2	----	^{c}43.6	27.0	----	----
1928	25.0	^{a}24.6	31.1	^{b}40.4	^{a}53.0	61.6	^{b}68.5	^{c}70.1	^{a}55.9	^{c}51.3	38.6	30.2	45.9	—0.6
1929	22.3	22.5	38.6	^{b}47.0	^{a}52.2	----	^{c}66.8	^{f}60.8	^{c}59.1	^{a}45.5	^{a}35.5	28.8	----	----
1930	24.8	30.8	31.8	----	^{c}56.4	^{b}63.5	^{b}67.2	65.6	^{b}63.0	^{a}46.6	37.2	25.9	----	----
1931	^{a}25.2	28.4	32.6	^{a}43.8	53.8	62.9	^{a}70.8	^{a}67.4	65.2	50.8	45.4	34.9	48.4	+2.2
1932	37.6	^{b}30.6	29.6	42.6	^{a}54.4	63.4	^{a}66.2	^{b}65.0	^{b}61.6	^{b}50.9	35.9	28.0	47.2	+1.0
1933	32.9	^{a}26.0	32.0	49.4	58.8	67.2	69.1	68.2	64.2	49.8	36.0	29.0	48.6	+2.4
1934	29.1	13.2	30.2	45.1	58.4	70.2	71.9	65.2	64.0	----	40.0	26.3	----	----
1935	22.8	23.2	37.8	42.9	50.6	63.2	71.6	67.6	57.8	47.0	39.3	22.4	45.5	—0.7
1936	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1937	32.9	27.6	^{a}29.8	44.4	59.7	64.6	68.5	70.6	56.8	46.7	^{c}36.0	25.0	46.9	+0.5
1938	24.8	31.5	37.4	46.0	54.9	62.5	68.2	70.6	61.1	58.8	----	31.6	----	----
1939	24.8	26.2	30.6	39.8	59.6	64.5	66.2	----	59.0	48.6	34.6	30.7	----	----
1940	13.8	22.8	26.8	43.2	52.4	62.9	65.3	59.9	----	----	37.5	32.0	----	----

* U. S. Weather Bureau "Climatological Data."
Letters of alphabet denote number of days missing.

*Monthly and Annual Precipitation**

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual	Departure from normal
1916	3.72	2.38	3.61	2.99	4.18	6.91	2.10	1.03	4.36	2.84	2.26	1.23	37.61	—2.63
1917	2.71	—	1.43	0.66	4.04	5.00	2.97	2.15	1.39	6.98	0.48	1.56	—	—
1918	2.64	1.72	—	—	—	4.95	2.93	4.00	2.65	1.45	0.92	1.70	—	—
1919	—	2.95	3.32	2.38	6.85	2.96	2.38	6.80	2.49	6.40	2.71	2.24	—	—
1920	3.02	2.30	1.65	—	1.54	5.97	3.59	3.02	4.53	1.55	3.31	2.91	—	—
1921	3.04	1.41	4.49	1.53	2.20	2.95	5.36	4.30	7.96	2.52	6.21	3.16	45.13	+ 5.17
1922	1.62	1.47	5.28	4.78	1.70	2.78	1.96	3.79	0.58	2.28	1.59	4.32	32.15	— 7.89
1923	4.00	2.20	1.43	1.17	4.77	2.17	3.03	3.29	1.77	1.41	2.85	5.59	33.68	—6.63
1924	4.55	2.37	2.39	3.62	—	5.09	3.59	3.54	6.48	0.31	0.96	2.64	—	—
1925	3.07	2.10	2.31	1.43	3.80	2.85	2.68	0.94	2.71	3.30	5.39	—	—	—
1926	1.85	1.34	—	0.85	1.13	5.05	1.49	6.59	5.75	4.59	2.40	3.16	—	—
1927	3.85	3.14	3.35	2.95	4.70	3.85	3.90	3.20	1.88	—	5.85	6.20	—	—
1928	1.45	2.73	3.25	4.20	1.75	9.81	4.85	4.35	2.37	3.67	5.23	1.43	45.09	+ 4.78
1929	4.42	2.94	3.41	6.37	6.00	—	5.05	0.50	2.55	7.39	3.40	3.36	—	—
1930	4.69	2.50	3.18	4.03	2.20	3.31	3.56	0.62	1.55	0.96	1.76	1.90	30.26	—10.05
1931	1.08	2.22	2.21	3.88	4.89	4.88	4.60	1.92	3.11	1.46	2.47	5.02	37.74	— 2.15
1932	7.48	1.49	2.29	2.31	2.42	3.24	4.55	1.66	1.84	3.63	4.43	3.09	38.43	— 1.27
1933	1.58	2.16	5.29	3.69	5.82	2.71	2.77	3.88	2.47	1.72	3.20	4.02	39.31	— 0.38
1934	2.61	1.20	2.59	2.19	0.96	3.68	4.49	6.05	3.33	2.36	3.79	2.30	35.55	— 4.21
1935	3.78	2.92	2.43	1.61	4.72	4.74	9.60	6.00	3.15	2.05	2.87	3.85	47.72	+ 7.96
1936	3.27	2.21	8.43	3.11	2.94	2.49	3.61	4.85	1.61	4.92	3.82	4.61	45.87	+ 6.29
1937	8.57	2.36	2.10	7.01	4.22	5.33	4.01	3.52	2.41	5.01	2.02	4.45	51.01	+11.43
1938	3.63	3.85	5.02	4.74	4.12	6.04	4.49	2.02	3.35	2.02	3.18	1.83	44.29	+ 4.71
1939	3.47	4.77	5.45	3.07	1.47	3.27	4.46	2.60	2.59	3.90	1.17	3.22	39.44	— 0.14
1940	1.89	3.66	4.37	5.61	4.03	5.04	2.18	2.31	3.49	0.85	4.34	4.14	41.91	+ 2.33

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* U. S. Weather Bureau, "Climatological Data."

Climatological data—Brookville Weather Bureau Station

Year	Temperature (degrees Fahrenheit)						Precipitation (inches)								Sky		
	Length of record in years	Annual mean	Highest	Date	Lowest	Date	Length of record in years	Total for year	Greatest monthly	Month	Least monthly	Month	Total snowfall unmelted	Number of days with .01 or more	Clear days	Partly cloudy days	Cloudy days
1916	6	45.8	98	Aug. 21	—26	Mar. 18	26	37.61	6.91	June	1.03	Aug.	52.9	98			
1917	7	42.9	96	July 31	—26	Feb. 13	27								172	106	84
1918	8		100	Aug. 6	—32	Feb. 5	28										
1919	9	47.2	96	July 5	—14	Dec. 17	29		6.85	May			17.8		198	83	72
1920	10	47.1	89	June 11	—20*	Jan. 4	30		5.97	June	1.55	Oct.	40.4		191	103	60
1921	11	49.1	96	July 5	—10	Jan. 26	31	45.13	7.96	Sept.	1.41	Feb.		111			
1922	12	47.2	94	July 11	—15	Jan. 25	32	32.15	5.28	Mar.	0.58	Sept.		92			
1923	13	45.8	101	June 24	— 5*	Feb. 7	33	33.68	5.59	Dec.	1.17	Apr.	33.5		223	58	84
1924	14		92	Aug. 6*	—23	Feb. 24	34				0.31	Oct.	48.5				
1925	15		97	Aug. 31	—27	Jan. 28	35										
1926	16	43.8	96	July 21	—19	Jan. 29	36										
1927							No data										
1928	17	45.9	93	Aug. 3	—13	Jan. 30	37	45.09	9.81	June	1.43	Dec.	35.0	103	197	88	81
1929	18				—20*	Jan. 16	38				0.50	Aug.	49.5				
1930	19		100	Aug. 4	—23	Jan. 26	39	30.26	4.69	Jan.	0.62	Aug.	36.9	119	217	65	83
1931	20	48.4	98	July 3	— 9	Jan. 2	40	37.74	5.02	Dec.	1.08	Jan.	27.5	122	196	56	113
1932	21	47.2	98	Sept. 2	—14	Dec. 16	41	38.43	7.48	Jan.	1.49	Feb.		126	206	48	112
1933	22	48.6	101	July 24	—16	Feb. 13	42	39.31	5.82	May	1.58	Jan.	53.0	124	138	85	142
1934	23		98	July 26	—30	Feb. 28	44	35.55	6.05	Aug.	0.96	May	38.4	114	131	123	111
1935	24	45.5	95	July 20	—13	Dec. 29	45	47.72	9.60	July	1.61	Apr.	54.4	150	108	98	159
1936	25	45.5	100	July 10	—27	Feb. 20	46	45.87	8.43	Mar.	1.61	Sept.		171	82	107	177
1937	26	46.9	92	July 9	—12	Dec. 14	47	51.01	8.57	Jan.	2.02	Nov.	32.7	166	89	89	187
1938	27		96	Aug. 15	— 3	Jan. 28	48	44.29	6.04	June	1.83	Dec.		160	78	102	185
1939	28		93	July 7*	—10	Jan. 26*	49	39.44	5.45	Mar.	1.17	Nov.	41.9	162	92	54	219
1940	29	†	94	July 25	—11	Jan. 7	50	41.91	5.61	April	0.85	Oct.	53.1	174	66	42	257

* Other days also. † Temperature records incomplete in years lacking annual mean.

Climate

The climate of the quadrangle is moderate, with a few days of oppressive heat in the summer and brief periods of sub-zero temperature in the winter. The summer nights are cool and refreshing. Heavy fogs are common in the fall. The mean annual temperature is about 46.5° F., the mean annual rainfall about 40 inches. U. S. Weather Bureau data from 1916 to 1938 indicate a total annual snowfall (unmelted) of 40 inches, varying from 17.8 inches in 1919 to 54.4 inches in 1935. The average length of the growing season is 113 days. The following table taken from U. S. Weather Bureau's "Climatological Data" gives the dates of the last killing frost in spring and the first in autumn as reported at the Brookville Weather Bureau Station.

Killing frosts or freezing temperature

Year	Last in spring	First in autumn	Year	Last in spring	First in autumn
1926	June 4	October 8	1933	June 15	October 3
1927	June 16	September 20	1934	May 27	August 30
1928	June 11	September 24	1935	May 26	September 11
1929	May 25	September 18	1936	May 31	September 2
1930	June 1	August 12	1937	May 21	September 18
1931	June 3	September 30	1938	May 25	September 26
1932	June 9	September 9	1939	May 15	September 18
			1940	May 11	September 26

Industries

When David and John Meade blazed the first trail by white men through this region in 1788 with all their goods packed on four horses, they found it thickly forested. It was this forest that led to settlement and development early in the nineteenth century. For years, lumbering remained the sole and chief industry of the region. Pine and hemlock predominated, but the forest included chestnut, oak, birch, sugar maple, ash, and hickory. Water-power sawmills probably operated here as early as 1820, for a sawmill was built at the mouth of Piney Creek, 14 miles west of Corsica in 1805. Great impetus was given the lumbering industry about 1847 when Maine and New York lumbermen became interested in the timber resources of the region. Logs were cut and floated down Redbank Creek to the Allegheny and thence to Pittsburgh, and beginning about 1820 sawed lumber was floated to market. Lumbering remained the principal industry until about 1900 when, as the timber became exhausted, interest was aroused in developing the coal and natural gas resources (pl. 5, A). During the first quarter of the present century coal mining was a thriving industry but, since the boom years following the war, it has gradually waned and in 1940 only a few mines were operating. The production of natural gas remains an important industry.

Clay is quarried and mined and manufactured into tile and brick at Brookville and Summerville. Extensive clay deposits within the quadrangle are undeveloped.

PLATE 5

A. Stump fence, all that remains of once thriving lumber industry.

B. Hanley Ceramics Company plant, Summerville.

PLATE 6

Humphrey Brick and Tile Company plant, Brookville.

The Humphrey Brick and Tile Company has a large plant on the eastern edge of Brookville (pl. 6). Clay is quarried and trammed a quarter of a mile to the plant, and made into face brick, hollow tile, and special tile products. The plant has about 20 beehive kilns. For many years the company has experimented with different types of glaze and with new tile products.

The Hanley Ceramics Company at Summerville (pl. 5, B) has a large and well-equipped plant which manufactures buff face brick, frit-glaze brick, and a variety of other products. The clay is mined half a mile north of the plant and trammed to jaw crushers at the plant. Two Hanley auger machines, a Boyd press, and several gas-fired 2-way tunnel kilns further process the clay to the finished products.

Another large industry in the quadrangle is the repairing of railroad equipment by the Pittsburg & Shawmut Railroad Company at shops in Brookville.

The Brookville Locomotive Works, two planning mills, a furniture factory, glove factory, and several smaller enterprises are all located at Brookville.

During the last 15 years attention has been directed to developing and improving the agricultural resources of the region, particularly dairying, potato growing, and breeding of pure bred Berkshire hogs.

The soil in the Brookville quadrangle is of DeKalb type. The DeKalb series is derived from all the geological formations exposed in the quadrangle, and so, occupies different topographic positions. The surface soils are gray, light brown, or grayish yellow; the subsoils are yellow, with occasional gray and brown weathered areas occurring on lower slopes or in gently sloping, lower-lying positions where drainage is not thoroughly established. The soil material is frequently 3 feet or more thick on the lower slopes and level areas but bedrock is generally encountered within the 3-foot section. Much of the up-

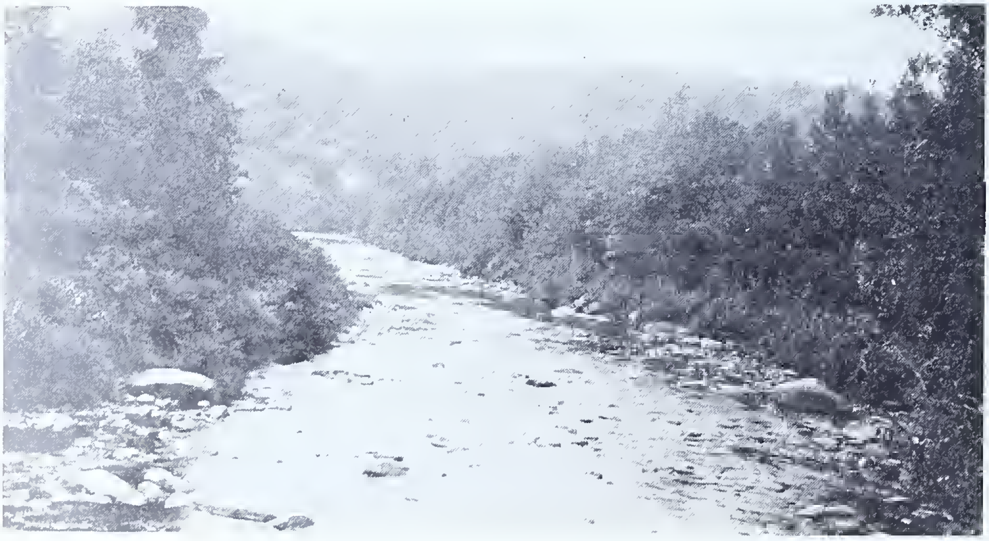

Figure 2. North Fork west of Richardsville.

land soil is of shale composition. The shale soils are favorable for potato growing. The use of lime with these shale soils encourages both legume production and dairy farming. The majority of farmers specialize in dairying. Today, this region is predominantly agricultural. The farms are mainly on the uplands. The major streams have cut deep ravines, particularly North Fork, Sandy Lick, Mill, and Redbank creeks. These ravines are densely wooded and provide good hunting grounds (fig. 2). Most of the northern part of the quadrangle is rocky and wooded and sparsely settled. A large area in the southeastern part is thick forest, part of which is a State game reservation.

Boroughs

Brookville, (4,397)[1] from which the quadrangle takes its name, is situated where North Fork and Sandy Lick Creek unite to form Redbank Creek (pl. 7, A). It was established as the county seat of Jefferson County in June 1830, and has essentially the aspect of a rural county seat.

Summerville (1,009)[1] is situated on Redbank Creek about eight miles southwest of Brookville (pl. 7, B). Here are located the mines and plant of the Hanley Company, manufacturers of refractory and face brick.

Ramsaytown (100) and Conifer (50) were formerly coal-mining towns, but the mines have been abandoned and only a few families remain. Other country villages are Corsica (481), Knoxdale (350), and Worthville (105). There is a fair-sized coal stripping operation at Corsica.

Transportation

The Brookville quadrangle is easily accessible by hard surface highways of recent construction. The Lakes-to-Sea Highway (Route 322), one of the principal trans-State highways, crosses the northern part of the quadrangle through Corsica and Brookville. A paved road (Route 28) from Pittsburgh follows the valley of Redbank Creek through Brookville northeastward to Brockway, Ridgway, and Bradford. A cement highway (Route 36) connects Brookville with Punxsutawney, the principal center of coal production and largest town in Jefferson County, and continues northward to Sigel, just north of the quadrangle. Route 536, from Punxsutawney to Mayport, crosses the southwestern part of the area. About 1930 some of the township roads were taken over by the State Highway Department and hard surfaced with macadam, notably the road from Brookville to Knoxdale, and from Brookville to Richardsville.

The quadrangle is served by four railroads, the Pennsylvania, the Pittsburg & Shawmut, the New York Central, and the Lake Erie, Franklin & Clarion.

The Low Grade division of the Pennsylvania Railroad, 437 miles by rail from Brookville to New York and 106 miles to Pittsburgh, traverses the valleys of Sandy Lick and Redbank Creeks.

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[1] Population 1940 census.

PLATE 7

A. Brookville, as seen from the west.

B. Summerville, as seen from the west. Hanley Ceramics Company plant on left.

The New York Central has trackage rights over the Pennsylvania east of Coder; west of there it operates over its own right of way to Franklin, Pa. and Ashtabula, Ohio, giving freight service to the Lake ports.

The Pittsburg & Shawmut, essentially a coal road, from Brockway to Freeport, traverses the eastern portion of the quadrangle. It has freight connections with the Baltimore & Ohio Railroad to Pittsburgh and direct connections with the Pittsburg, Shawmut & Northern and Erie lines to the Lake ports and northern markets.

The Lake Erie, Franklin & Clarion is a small road connecting with the Pennsylvania at Summerville and extending to Clarion. It serves the coal mines along Runaway Run, now largely abandoned. Every part of the quadrangle except the northern strip is within three miles of a railroad.

Bus lines operating on regular schedules over the Lakes-to-Sea Highway provide transportation service east and west between New York City and Akron, Ohio, with connections to Pittsburgh. A bus line also operates to Kittanning.

No water transportation is available within the region. In the early days iron ore was hauled overland to Brookville from the Centre County mines, transferred to flatboats and floated down Redbank Creek and Allegheny River to the Pittsburgh district. During the lumbering days, timber was rafted down Redbank Creek to Pittsburgh on floods.

The Brookville airport is on the southwestern outskirts of the borough along the highway to Pittsburgh and adjacent to the New York Central and Pennsylvania Railroads. It has an area of 70 acres with a landing field 2,400 feet long and 1,200 feet wide. It is an emergency landing field on the New York-Chicago section of the transcontinental air-mail route between Bellefonte, Pa. and Cleveland, Ohio.

TOPOGRAPHY

General Relations

Following the classification of Fenneman[1], the Brookville quadrangle is in the Kanawha section of the Appalachian Plateau province (fig. 3). This physiographic province is a broad maturely dissected plateau that extends from the Adirondacks in New York to northern Alabama. On the west this plateau merges more or less gradually into the Central Lowlands. Toward the east, the plateau province terminates in a well-developed escarpment known as the Catskill Mountains in New York, the Allegheny Front in Pennsylvania, Maryland, and West Virginia, and the Cumberland Front in Virginia, Tenessee, Georgia, and Alabama. East of this escarpment is the Ridge and Valley Province, a succession of low narrow parallel valleys and ridges underlain by highly folded early Paleozoic sediments.

In Pennsylvania the Appalachian Plateau province may be subdivided into three physiographic divisions known from west to east as the Southern New York section, the Kanawha section and the Allegheny Mountain section.

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[1] Fenneman, Nevin M., Physiographic divisions of the United States: Annals Assoc. of American Geographers, vol. 18, no. 4, Dec. 1928.

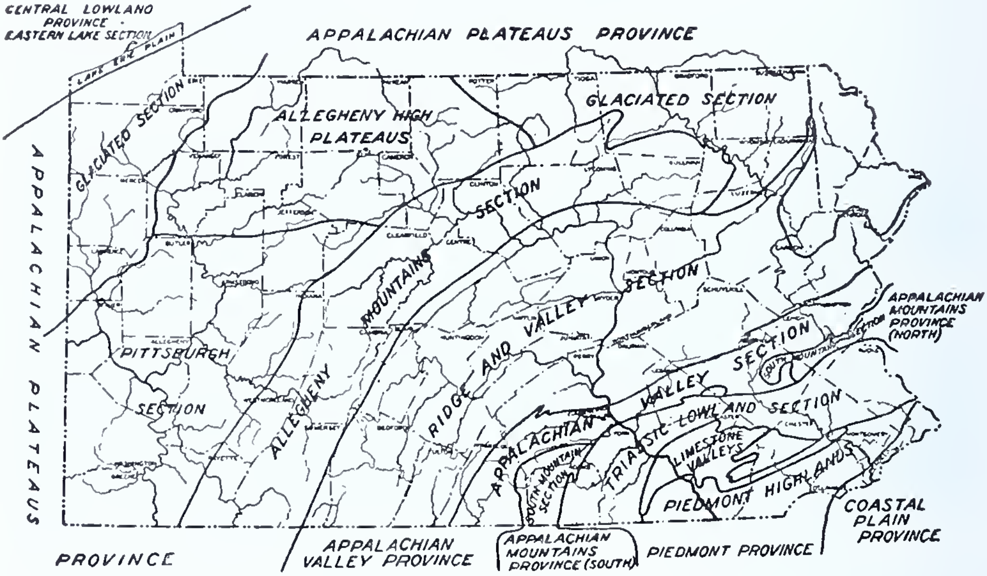

Figure 3. Physiographic subdivisions of Pennsylvania.

The Southern New York section is a glaciated region which gives a character to the topography in contrast to the Kanawha section. The boundary between the two is transitional but is generally placed where the effects of glaciation cease to be well marked.

The Kanawha section, in which lies the Brookville quadrangle, is a region of stronger relief and is more minutely dissected by tributary streams. Structurally this section consists of gentle folds in the southern part that pass into warped structures toward the north.

In contrast, the Allegheny Mountain section is affected by stronger folds which give rise to anticlinal ridges south of latitude 41 degrees, notably Chestnut Ridge, Laurel Hill, and Negro Mountain.

Viewed from the top of any of the higher hills, the general uniformity of elevation of the tops of the hills is the striking topographic characteristic of the area. This would indicate that at one time this region had been worn down by erosion to a plain of which these hilltops are now the remnants. Such a surface is called a peneplain, the word meaning almost a plain.

Figure 4 shows this peneplain in northwestern Pennsylvania as reconstructed by Ashley by contouring the summits of the highest hills. For example, in Jefferson County between the 1,800-foot and 1,900-foot contour lines there is no hill that rises above 1,900 feet in elevation. These summit contours show a surface sloping gently down toward the southwest to the region of the Ohio River and then rising toward the southwest. Ashley has called this the Allegheny peneplain. This peneplain was correlated by Campbell[1] with the peneplain

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[1] Campbell, M. R., Geographic development of northern Pennsylvania and southern New York: Geol. Soc. of America Bull., vol. 14, pp. 277-96, 1903.

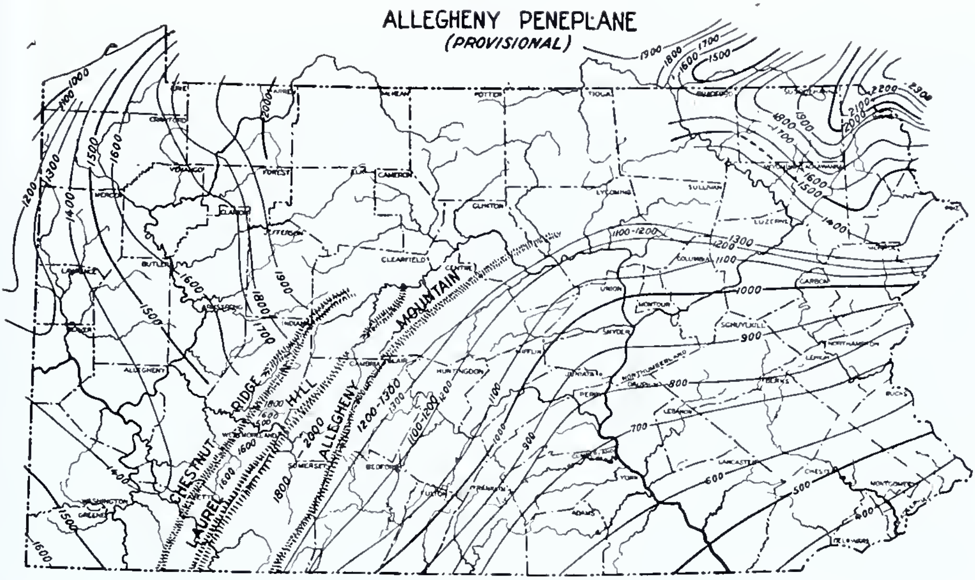

Figure 4. Sketch map showing the elevation of the Allegheny peneplain in the northwestern part of Pennsylvania.

developed at Harrisburg in the shale hills at an altitude of 500 feet which he called the Harrisburg peneplain. It was probably developed and uplifted in early Tertiary time. In the Brookville quadrangle this peneplain has been greatly dissected and it is doubtful if more than a vestige of the original surface remains. However, its effect on the topography is evident in the similarity of elevation of the higher hills.

Drainage

The Brookville quadrangle is drained almost entirely by Redbank Creek and its tributaries. North Fork flowing south and Sandy Lick Creek flowing west unite at Brookville in the northeastern part of the quadrangle to form Redbank Creek which flows southwest across the quadrangle, eventually emptying its waters into Allegheny River at Redbank Furnace, Clarion County. A small area in the northwest portion of the quadrangle is drained by Mill Creek, a tributary of Clarion River.

Redbank Creek pursues a tortuous course in a narrow valley with steep sides (pl. 8, A). This meandering course was probably developed on a peneplain surface and was maintained by the stream during the uplift of the region following the development of the peneplain. Three distinct ox-bow bends occur along its course in this quadrangle, one at Brookville, another between Baxter and Summerville, and another just below Heathville.

North Fork, the principal tributary of Redbank Creek from the north, rises in Polk Township in northern Jefferson County and follows a sinuous course for 20 miles through a narrow, steep-sided and densely wooded valley (see fig. 2) to Brookville, where it joins Sandy Lick Creek to form Redbank Creek. It is the source of Brookville's water supply.

PLATE 8

A. Redbank Creek at Patton Station, looking south.

B. Valley of Little Sandy Creek, looking east toward Worthville.

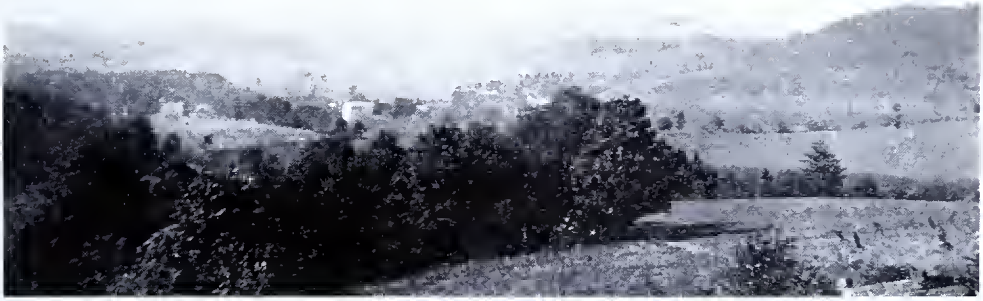

Figure 5. Looking west toward Cool Spring in the valley of Little Sandy Creek. Hilltops are Freeport and lower Conemaugh strata.

Sandy Lick Creek rises in Sandy Township in northwest Clearfield County and follows a circuitous course through Clearfield and Jefferson Counties for a length of 36 miles to join Redbank Creek at Brookville. DuBois, Reynoldsville, and Falls Creek are located on this stream and its waters are polluted by waste from coal mines, tanneries, and mills. The lower part of its course in the Brookville quadrangle is through a narrow, steep-walled, densely wooded valley which is followed by the Low Grade division of the Pennsylvania Railroad.

Mill Creek, tributary to Sandy Lick, has its source in Snyder Township near Brockwayville and flows southwest 17½ miles to empty into Sandy Lick Creek at Port Barnett, an eastern suburb of Brookville. In the Brookville quadrangle it runs in a narrow, steep-walled, thickly wooded valley that is followed by the Pittsburg & Shawmut Railroad.

Little Sandy Creek, the largest tributary on the east side of Redbank Creek, traverses the southern part of the quadrangle from McCalmont Township westward to its mouth in northern Armstrong County. Its course is 15 miles long through a broad valley to Langville, whence the valley becomes narrow, steep-sided, and very densely wooded. The villages of Cool Spring and Worthville are in the broad valley (pl. 8, B).

Mill Creek, tributary to Clarion River, heads in Eldred Township, flows south three or four miles, then turns sharply northwest and empties into Clarion River at Mill Creek in Clarion County. This stream likewise has steep valley walls that are densely covered with second growth forest. The divide between it and the drainage southward to Redbank Creek lies just north of the Lakes-to-Sea Highway and is occupied by the village of Corsica. The divide on the east between it and the waters of North Fork is followed by the road to Sigel, Route 36.

The volume of water in all these streams is extremely irregular and varies from raging torrents during flood periods to almost complete exhaustion in times of severe drought.

The following table gives the total area drained by the principal streams and their tributaries. For the larger streams, this includes area outside the quadrangle.

Area of Drainage Basins

Stream	Square miles	Stream	Square miles
Redbank Creek	585.5	Welch Run	3.8
North Fork	97.2	Runaway Run	3.0
Shippen Run	4.5	Beaver Run	8.1
Craft Run	3.9	Tarkita Run	2.9
Pekin Run	10.4	Little Sandy Creek	78.1
Red Lick Run	3.4	Indiancamp Run	7.0
Sugarcamp Run	1.5	Lick Run	3.3
Sandy Lick Creek	235.5	Big Run	18.3
Mill Creek	54.9	Reitz Run	3.7
Little Mill Creek	10.8	Ferguson Run	1.6
Fivemile Run	17.1	Cheny Run	5.3
Coder Run	9.8	Pine Creek	12.1
Campbell Run	2.9	Mill Creek (trib. to Clarion River)	55.5
Clement Run	1.5	Little Mill Creek	13.7

The drainage pattern of a region of this type, in which the main streams are entrenched and meander in their courses, has a distinct bearing upon the physical and economic development of the region. To obtain minimum grade, the railroads must follow the sinuous course of the streams, which adds many miles to the air-line distance between points; the main highways naturally tend to follow the upland divides; the farm lands are in general on the uplands since the stream valleys have few broad bottoms; and the steep sides of the main valleys are not fit to cultivate and are covered with dense woods.

Relief

The surface elevations of the quadrangle range between 1,080 and 2,060 feet above sea level. The average relief is 500 feet, the maximum 980 feet. The valleys are narrow, have steep sides and no flood plains (pl. 9, A). Large areas of flat or gently sloping land characterize the elevated portions of the quadrangle and agricultural development is chiefly confined to these uplands (pl. 9, B).

The southeastern part of the quadrangle has a topographic character different from that of the rest of the area. In general the elevation is greater; many of the hilltops are 1,800 feet in elevation, a few 1,900 feet and one, the highest in the quadrangle, is more than 2,040 feet high. This high point is 1¾ miles southeast of Green Valley. The hills tend to be narrow and sinuous, cut by narrow steep ravines tributary to the creeks, giving a pinnate expression to the topography.

The uplands in the northern portion of the quadrangle are broader and have flatter tops with broad flat spurs and noses that range between 1,600 and 1,700 feet in altitude. A few isolated knobs rise above this general level, notably the one in the northwest corner of the quadrangle on which is located a U.S.G.S. triangulation station at 1,912 feet above sea level. The tributary valleys and ravines are not so narrow as in the southeastern portion.

Across the central part of the quadrangle from northeast to southwest lies a strip of broad, flat upland incised by the steep and narrow

PLATE 9

A. North Fork, one mile north of Brookville.

B. View eastward toward Richardsville, Eldred Township.

valleys of Redbank, North Fork, and Sandy Lick Creeks. The general hilltop elevations in this strip are lower, averaging between 1,500 and 1,600 feet in the southwest and between 1,600 and 1,700 feet in the northeast. These lower hilltop elevations are probably the result of nearness to the main drainage.

Relation of the topography to the geology

The general character of the topography seems to bear no direct relation to local geologic conditions but rather to regional factors such as the formation of the Allegheny peneplain, its subsequent uplift and dissection by the streams, independent of the geologic formations and their structure.

The principal streams maintain their courses without regard to geologic structure. Redbank Creek does follow very closely the trough of the Fairmount syncline from Brookville to Summerville, but here it veers sharply to the south and flows across the sharply rising northwest flank of the North Freedom anticline nearly to its crest, whence it turns southwestward again and flows down structure toward the Fairmount synclinal axis. Little Sandy Creek also flows westward, traversing the structure without any apparent reflection in the course of the stream.

There appears to be no apparent geologic reason for the generally higher average elevation of the southeast part of the quadrangle. Here the uplands are underlain by the Allegheny and Conemaugh formations which are dominantly shales with some sandstone beds. This fact may, however, account for the deep and narrow tributary ravines and the pinnate shape of the hills in contrast to other parts of the quadrangle. Here, the cover of more easily erodable shales and sandstones is thickest and the more resistant thick-bedded sandstones of the Pottsville formation crop out over only a small area in the vicinity of Sprankle Mills and East Branch. Hence, the streams have a greater thickness of soft beds to cut through and the resistant sandstones are above water level in only a small area.

In the northern part of the quadrangle, another region of high land, the uplands are underlain by shales of only the lower part of the Allegheny formation. The resistant massive sandstones of the Pottsville crop out high up on the valley sides. Here the uplands are broad and flat with broad spurs, and although the main streams are incised in steep-sided, narrow valleys, the tributary drainage is not so well developed and occupies shallower and broader valleys than in the southeast section. This is undoubtedly the result of the more extensive outcrop of the massive Pottsville sandstones and their occurrence high up on the valley sides, overlain by only a shallow covering of Allegheny shales.

The central strip of lower land close to the main drainage has an extensive covering of Allegheny and Conemaugh shales in the uplands, with the Pottsville sandstones cropping in the main valleys. The lower elevation of the uplands is no doubt due to the nearness of the main drainage. The only apparent geologic effect is the steep and boulder-strewn valley walls where the Pottsville sandstones crop out. Except in the immediate vicinity of Summerville, where the Pottsville sandstone barely reaches the surface in the Fairmount syncline, the valley sides of Redbank Creek and its tributaries, North Fork and Sandy Lick Creek, are steep, strewn with masses of Pottsville sandstone, and consequently unsuited for farming. These valley sides are densely covered with second growth timber and abound in small game. Deer are not uncommon.

It is important to emphasize this lack of relationship between topography and geologic structure because some prospectors for gas have held the theory that gas occurs under the hills. This may be due to a misunderstanding of the anticlinal theory that gas tends to accumulate in structural highs. However, an area that is structurally high is not necessarily reflected by high land or hills at the surface in this region; it may be reflected by a valley. The surface contour of the hills is controlled by the underlying beds, and the surface contour may indicate the nature of the underlying rocks. In general, hills capped by shale tend to be evenly rounded, while massive sandstone beds form flat-topped hills with steeper slopes. Layers of massive sandstone with intervening softer rocks form distinct benches that may be traced from hill to hill. Very often a succession of benches on a hill slope indicates the position of a succession of coal beds with their accompanying soft clays and shales. This is frequently the only means of tracing the crop of a particular coal bed from one hill to another in this region where outcrops are few.

Physiographic History

The character and appearance of the present surface or physiography of the Brookville quadrangle have been outlined. This is the result of a succession of geologic processes operating over a long period of time. The story begins approximately 540 million years ago when this region was a depressed area fluctuating from slightly below sea level, when it was occupied by a vast shallow inland sea resembling the present Hudson Bay, to slightly above sea level. During this long period of time, the present rocks were laid down as sediments in this depressed area. The type of sediment varied with changing conditions so that a succession of shale, sandstone, limestone, coal, and clay beds gradually accumulated as this depressed area slowly, but gradually subsided. Toward the close of this era, conditions became more nearly stabilized near sea level and extensive swamps developed, in which enormous quantities of vegetable matter accumulated. During intermittent periods of depression, the area subsided enough to allow deposition of more sediments on top of this vegetable debris. In this manner, the material accumulated which now composes the rocks exposed at the surface and to a depth of 7,000 feet beneath the surface in the Brookville quadrangle. About 200 million years ago, after many million years of sedimentation, a tremendous event occurred in the geologic history of Pennsylvania. Geologists call it the Appalachian Revolution. Dynamic earth forces directed from the southeast lifted these sediments above sea level and, as they were being raised, folded and squeezed them severely in central and eastern Pennsylvania, but only slightly into a series of gentle folds in the Brookville quadrangle and elsewhere in western Pennsylvania. Since then, this area has been above sea level and subject to the erosional processes of weathering and stream action.

Drainage lines were established on this new land area and erosion gradually reduced the entire area to a region of broad flat hills and wide valleys. Such a nearly leveled surface is called a peneplain. This broad flat surface probably was developed in Tertiary time, some 60 million years ago.

The horizon as viewed from a high point anywhere in the quadrangle reveals a nearly level line which suggests that these concordant hilltops at nearly the same elevation are the remnants or at least the reflection of this former peneplain. This has been called the Allegheny peneplain by Ashley* from its fine development in the Allegheny River region of Forest and Venango Counties.

The present courses of the main streams, such as Redbank Creek, probably developed on this peneplain. The meandering nature and numerous oxbows of Redbank Creek suggest a course that could only be developed on an essentially flat surface.

The final chapter in the development of the present surface features was initiated by a gradual uplift of the region without folding or faulting of the rocks. This enlivened the sluggish meandering streams so that they renewed the process of downward cutting and maintained their courses during the uplift. Thus, today, the main streams are winding incisions in the old peneplain surface with the generally concordant hilltops the only reminder of the former peneplain.

STRATIGRAPHY

General Description

All the rocks of the Brookville quadrangle consist of shale, sandstone, conglomerate, limestone, coal and clay, which are of Paleozoic age, and sedimentary in origin. No igneous or metamorphic rocks occur in the region. The material which composes the sedimentary rocks was transported and deposited as sediments in water. Probably most of the material was deposited under continental conditions, but some is quite definitely marine, such as the Vanport limestone which contains marine fossils. The coal beds represent the accumulated organic debris of ancient swamps. All occur as beds or strata, ranging in thickness from paper-thin shale or clay layers to massive sandstone beds 30 feet or more thick. The rocks exposed at the surface have a total thickness of about 1,000 feet. About 3,500 feet more of the underlying rocks have been penetrated by the drill in the search for oil and gas.

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* Ashley, Geo. H., The Scenery of Pennsylvania: Penna. Topo. and Geol. Survey, Bull. G 6, p. 23, 1933.

All the exposed rocks belong to the Pennsylvanian and Mississippian systems of the Carboniferous period (''age of coal''), and were formerly termed the ''Coal Measures.'' For the purpose of mapping, it has been convenient to subdivide the Pennsylvanian system into several rather arbitrary groups. The lower members of the Conemaugh group occupy the higher land in the southeast portion of the quadrangle. Small remnants cover a few of the higher hills west of Summerville. The principal outcropping rocks of the quadrangle belong to the Allegheny group which includes all the strata between the Upper Freeport coal and the underclay of the Brookville coal. In the valleys of the main streams and some of their principal tributaries the sandstones of the underlying Pottsville series make a conspicuous showing. The thickness of the Pottsville is probably about 200 feet. In a few places, notably the valley of Redbank Creek near Patton Station and the ravines of Mill Creek and North Fork, the oldest exposed rocks appear, namely the upper members of the Pocono series of Mississippian age.

Considering the quadrangle as a whole the rocks are poorly exposed. The uplands are generally flat or gently rolling, covered by a mantle of soil and vegetation so that outcrops are very few. Some of the newer road cuts have revealed the nature of the bedrock but these exposures are scattered. Although the main streams have cut deep valleys, the valley walls seldom reveal exposed rocks since they are densely wooded and covered with talus. A detailed section could not be obtained in any valley. The small tributary streams are filled with this talus wash and seldom yield an exposure of bedrock.

While sedimentary rocks occur in distinct layers, detailed study of the stratigraphy reveals variability of the beds that in some places is bewildering. A massive, coarse-grained sandstone bed may become fine-grained and shaly a quarter or half a mile away, or may even grade into shale. For this reason the sandstone members are very unsatisfactory and treacherous horizons to work with in deciphering the geology. Since no well-defined horizon could be recognized in the northern and northeastern part of the quadrangle, the geology had to be worked out by attempting to recognize and trace some one sandstone horizon, especially the sandstone at the top of the Pottsville series. It is quite possible that other sandstone layers above and below may be confused with the expected massive sandstone at the top of the Pottsville so that the geologic mapping of this area is not as certain as could be wished. In other parts of the quadrangle, the Vanport limestone is a very valuable and definite key horizon. Although it underlies about two-thirds of the quadrangle, only three outcrops were observed, but fortunately, many farmers at one time or another have dug into it for lime so that its outcrop could be traced accurately. Over more restricted areas, several of the coal beds, especially the

Upper Freeport, Lower Kittanning, and Brookville, can be traced for some distance and therefore are excellent markers, especially since these coals have been mined locally and in some cases extensively in the recent past. In general it is believed that the succession of rocks has been determined correctly and that the upper and lower boundaries of the Allegheny group are correct within 25 feet.

To illustrate the extreme variability sometimes observed in the rock succession within short distances, the following sections obtained in the hills surrounding Brookville are presented:

Geologic section in hill west of Brookville

Compilation of road sections along routes 28, 36, and 322

Elevation Feet		Thickness		Total	
		Ft.	in.	Ft.	in.
1580	Top of hill				
	Concealed	30		30	
1550	Lower Kittanning coal	2		32	
	Concealed	10	6	42	6
	Shale, sandy, olive-green	10		52	6
	Gray shale with siderite concretions	15		67	6
	Clay	1	6	69	
1510	Vanport limestone	3		72	
	Carbonaceous shale	0	4	72	4
	Fire clay	?			
	Sandy shale	5		77	4
	Shale, weathers yellow brown	23	8	101	
1480	Coal blossom, Upper Clarion	1		102	
	Clay blossom	?			
	Concealed	6		108	
	Sandstone, thin bedded, slabby	10		118	
	Shale, weathers yellow brown	15		133	
1450	Coal blossom, Lower Clarion	1	6	134	6
	Fire clay	5		139	6
	Reddish clay, siderite concretions	6		145	6
	Shale	3		148	6
	Sandstone	0	3	148	9
	Shale	3		152	9
	Concealed	17	3	170	
1415	Shale and carbonaceous shale	?			
	Concealed	10		180	
	Shaly sandstone, yellowish	15		195	
	Sandstone	10		205	
	Concealed	10		215	
	Massive sandstone	10		225	
	Concealed	50		275	
	Massive sandstone	10		285	
1270	Main Street, Brookville				
	Concealed — probably sandstone	70		355	
1200	Redbank Creek				

Section in Tunnel Hill, South Brookville

Up west side of hill and along Route 36.

Elevation Feet		Thickness Ft.	Thickness in.	Total Ft.	Total in.
1472	Sandstone, white, medium-grained ...	18	0	18	0
1470	Caved coal bank, opposite cemetery ..	1	6	19	6
	Concealed	22	6	42	0
1437	Sandstone	11	9	53	9
1432	Shale, brown, hackly	5	0	58	9
	Concealed	16	0	74	9
1410	Sandstone, shaly, olive-green	5	8	80	5
	Shale and sandstone, thin-bedded	11	2	91	7
	Sandstone	6	0	97	7
1390	Caved coal banks, Brookville				
1383	Clay, plastic grey	10	0	107	7
	Shale, brown, sandy, thin	3	6	111	1
	Concealed	5	0	116	1
	Sandstone, tan, massive (Homewood) .	20	0	136	1
	Coal	1	8	137	9
	Clay	0	3	138	
	Coal	0	3	138	3
	Clay	2	6	140	9
	Concealed	17	0	157	9
	Coal bloom				
1330	Clay, flinty	1	0	158	9
	Concealed	11	0	169	9
	Coal	0	8	170	5
1230	Sandstone, yellow-white	84	0	254	5
1200	Concealed to Redbank Creek	36	3	290	8

Section in Litchtown Hill, East Brookville

Combined road section along Route 322 and old Humphrey quarry section

1480	Top of hill				
	Concealed	15		15	0
1455	2 Caved coal banks (Clarion)	1	2	16	2
	Concealed	17	0	33	2
	Sandstone, thin brown	20	0	53	2
1419	Coal (Brookville), top of quarry	1	3	54	5
	Clay, grey plastic	3	0	57	5
	Clay, sandy	2	0	59	5
	Shale, sandy	8	1	67	6
	Shale, hackly, sandy	2	9	70	3
	Shale, black, fissile	1	0	71	3
	Shale, drab-green	5	6	76	9
1390	Shale, black, fissile	11	4	88	1
1390	Quarry floor				
1365	Sandstone, mostly concealed	50		138	1
	Shale	3		141	1
	Clay	0	10	141	11
	Shale	7		148	11
	Shaly coal	0	10	149	9
	Coal	2	6	152	3
	Clay	1	6	153	9
	Shale	3	6	157	3
1315	Coal	2	6	159	9
	Sandy clay	0	2	159	11
	Sandstone	3		162	11
	Concealed	10		172	11
	Sandstone, white	60		232	11
	Concealed	10		242	11
1220	Sandy Lick Creek				

The Mercer group includes the beds from coal at 1315 feet to the shale under sandstone at 1365 feet.

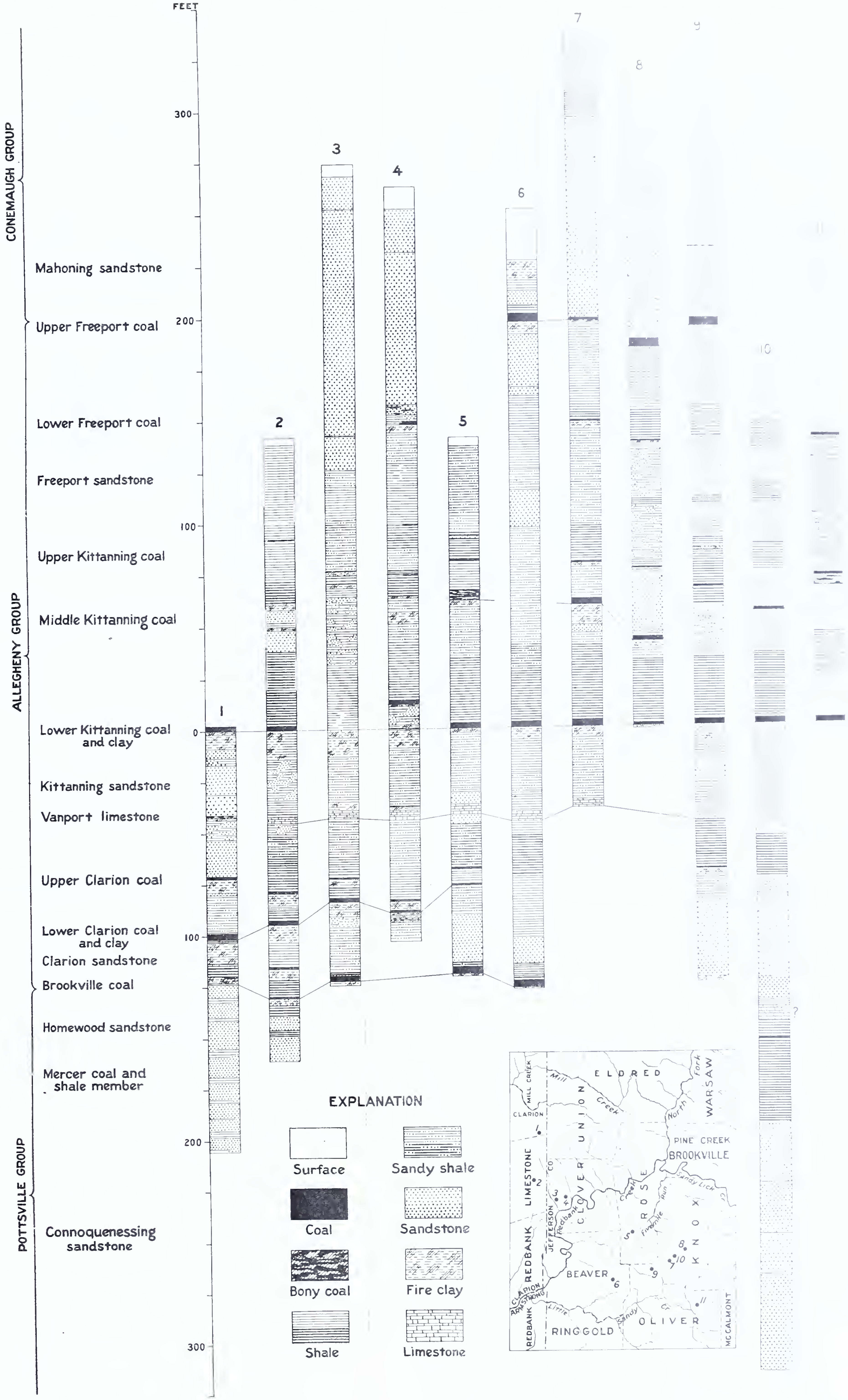
The accompanying sections show the average stratigraphic succession for the whole area. (See plate 10.) The upper part is constructed from numerous measured sections along roads, in railroad cuts and quarries, and from many drill records. More than a thousand wells have been drilled in the quadrangle in search for natural gas. Many of these have been drilled into the Chemung formation of the Devonian series. From the records of some of these wells it has been possible to obtain information regarding the nature of the rocks lying below those exposed at the surface. These formations will be discussed in the section relating to the occurrence of natural gas in the quadrangle.

This region is a part of the extensive area known as the great bituminous coal field of western Pennsylvania. The rocks were deposited in the Appalachian geosyncline, a great down-warped area that, during the greater part of Paleozoic time, was occupied by an epicontinental sea. In this down-warped area a total thickness of some 40,000 feet of sediments accumulated. The sinking of the basin in general kept pace with the deposition of the sediments, but was interrupted many times during Paleozoic time by regional uplift. The retreats and advances of the sea accompanying these uplifts and subsidences produced breaks and overlaps in the rock succession. While mud or lime deposits were being laid down in one area, sand may have been deposited in another. This resulted in the interlensing of beds so characteristic of the Appalachian region. A pronounced stratigraphic feature of the Appalachian area is the general increase in thickness of the sediments from west to east approaching the old land mass which was the source of the sediments.

Because of this common origin of sediments, and because they have been subjected to the same natural forces since their deposition, the resulting rocks are similar in kind and attitude. Sand became sandstone; mud became shale; limestone resulted from the consolidation of lime muds probably deposited by marine organisms, algae and bacteria, and by chemical precipitation; coal beds have originated from the accumulated vegetable matter in ancient swamps and bays. Obviously the lowest beds were deposited before those above and are therefore older. The beds may be distinguished by peculiarities of composition, thickness, color, and sometimes by study of the fossil shells and plants contained in the rocks. In this way, the rocks have been divided into systems and subdivided into groups and formations for the convenience of study and mapping.

PENNSYLVANIAN SYSTEM

The Pennsylvanian system embraces the principal coal-bearing formations of the stratigraphic column. The system is named for this State because of the economic importance of its coal beds and the fact that these rocks were first studied and the stratigraphic succession worked out in this region. The Pennsylvanian system has been subdivided into four parts or groups, named from the top downward: Monongahela, Conemaugh, Allegheny, and Pottsville. All of the Monongahela and most of the Conemaugh have been eroded so that



Drill records showing stratigraphic succession and variability of strata.

Monongahela and most of the Conemaugh have been eroded so that the Pennsylvanian system is only partly represented in this area. The part of the Pennsylvanian present in the Brookville quadrangle, as shown by the selected sections, plate 10, totals about 825 feet, and is distributed among three groups as follows: Conemaugh, 300 feet exposed; Allegheny, 325 feet; Pottsville, approximately 200 feet. The records shown on plate 10 are from:

1. DeHaven Coal Company, Corsica.
2. Kezia Davis farm near Sutton.
3. Hanley Ceramics Company, No. 6.
4. Hanley Ceramics Company, No. 3.
5. Allegheny River Mining Company, No. 127.
6. Allegheny River Mining Company, No. 115, Jonathan Reitz farm.
7. Shawmut Mining Company, No. 21, Swabb farm.
8. Shawmut Mining Company, No. 1, Cummings farm.
9. Shawmut Mining Company, No. 88, Millen farm.
10. Water well at Ramsaytown, Shawmut Mining Company, No. 22.
11. Atlantic Coal Company, No. 3, East Branch.

CONEMAUGH GROUP

The Conemaugh group, formerly called the "Lower Barren Coal Measures," takes its name from the valley of the Conemaugh River along which it crops. It includes all the rocks between the top of the Upper Freeport coal and the base of the Pittsburgh coal. Most of the Conemaugh has been removed by erosion in this quadrangle so that only the lower part remains, occupying the higher hilltops. It crops out from Knoxdale and Ramsaytown southwestward to Ringgold Township and is coextensive with the Worthville syncline. Small patches also occur in the Fairmount syncline west of Summerville. The nearest complete occurrence of the Conemaugh group is in Armstrong and Indiana Counties, where it is 650 feet thick. Only the lower 300 feet remain in this quadrangle in the high hills 1½ miles south of Ramsaytown (fig. 5). Usually much less is preserved.

Exposures of the Conemaugh are very poor and exceedingly scarce. Comprising the hilltops, it is usually above the roads and hidden by soil and vegetation. Fortunately, the prospecting for coal by drill in the vicinity of Ramsaytown has revealed the nature of the Conemaugh in this region. It appears to be exceedingly varied in character and composed principally of sandstone and shale with a few thin limestone beds and economically unimportant coal seams.

The sections shown on figures 6 and 7 are in the Ramsaytown area. They reveal how exceedingly variable the succession is over a very limited area. Three limestone horizons appear at 35, 65, and 125 feet respectively above the Upper Freeport coal. The lower of these is an unnamed horizon at which limestone has been found in adjacent areas. Ashley reports it in the Punxsutawney quadrangle. It is apparently not persistent. The limestone at about 65 feet above the Upper Freeport coal may represent the Mahoning limestone, and that at 125 feet is probably in the Brush Creek horizon. These limestones are locally called the "summit lime" by the farmers. The two lower limestones were considered the Upper Freeport limestone by Platt in the Second Survey report on Jefferson County, but for reasons expressed in the discussion of the Upper Freeport coal on page 34, it has been considered more reasonable to place them in the Conemaugh. In southern Knox Township about three-fourths of a mile south of the road intersection indicated as 1,701 feet elevation, a limestone was dug at an elevation of 1,800 feet. This would appear to be about 200 feet above the Upper Freeport coal and may represent the Woods Run limestone. It was reported by the farmers who dug it to be about three feet thick, bluish in color and overlain by 15 feet of drab shale.

The coals above the Upper Freeport are all thin and of no economic importance. A one-foot bed of coal was revealed by the drill at about 150 feet above the Upper Freeport coal and may represent the Bakerstown. In a high hill near the southern boundary of Knox Township between Lick Run and Indiancamp Run, about one foot of coal crops in a lane. This coal was once prospected by an old drift which did not reveal coal of workable thickness. It occurs at an elevation of about 1,725 feet, approximately 125 feet above the Upper Freeport. This may be the Brush Creek horizon.

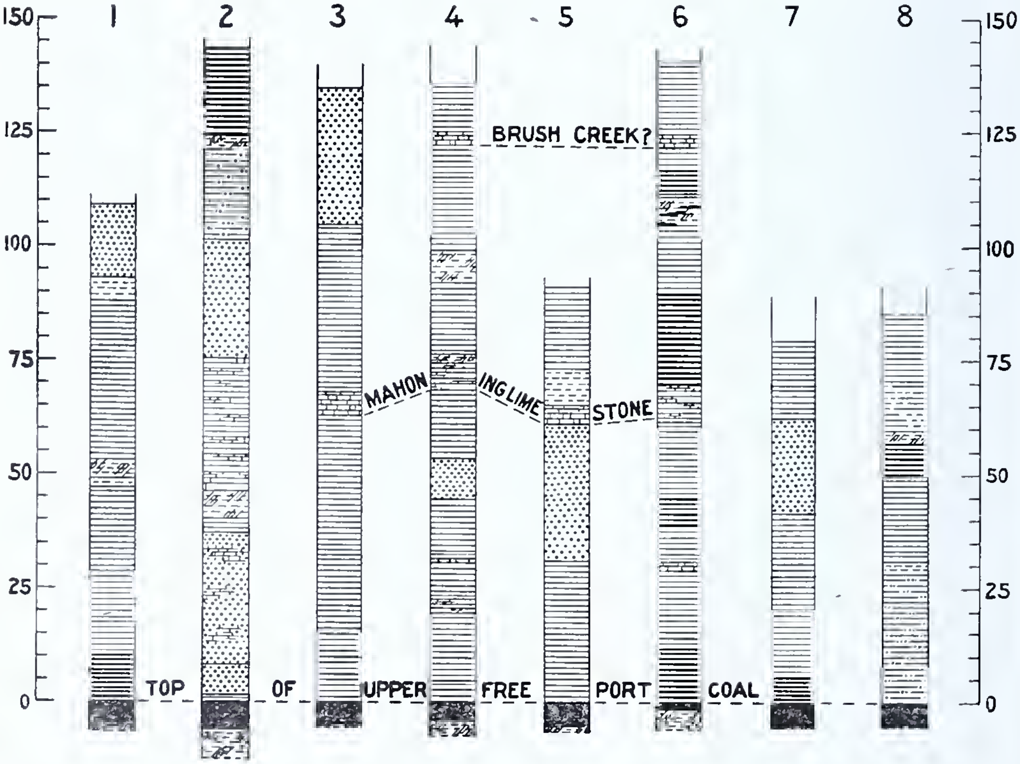


Figure 6. Sections of Conemaugh group in Jefferson County from core drill records of Shawmut Mining Company.

1. Henderson farm, Rose Township.
2. J. B. Henderson farm, Oliver Township.
3. Millen farm, Oliver Township.
4. T. T. Millen farm, Oliver Township.
5. T. T. Millen farm, Oliver Township.
6. Kinnear farm, Oliver Township.
7. Millen farm, Oliver Township.
8. T. Treharne farm, Oliver Township.

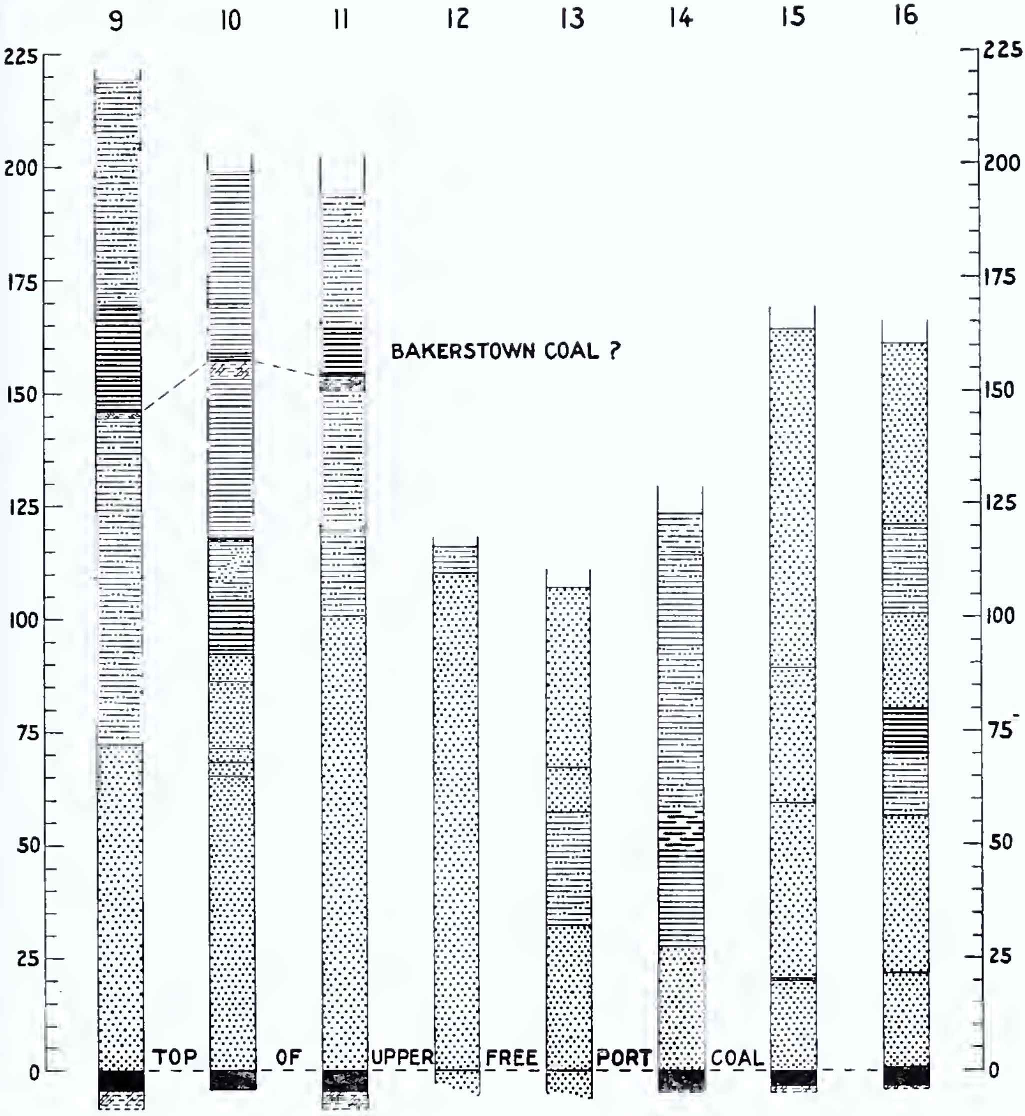


Figure 7. Sections of Conemaugh group in Jefferson County from core drill records of Shawmut Mining Company.

9. Swabb farm, Knox Township.
10. Swabb farm, Knox Township.
11. Swabb farm, Knox Township.
12. George Smail farm, Knox Township.
13. Smail farm, Knox Township.
14. John Byerly farms, Knox Township.
15. Stahlman farm, Knox Township.
16. Jeff Jones farm, Knox Township.

Mahoning sandstone member. The lower part of the Conemaugh group is generally occupied by a succession of green to buff sandstones and shales. In places the sandstone becomes fairly massive. It is sometimes separated into two or three sandstone horizons by shale beds. Where two sandstones occur, they are sometimes separated by red clay, coal, and limestone beds which occur about 50 to 60 feet above the Upper Freeport coal. Most of the drill records in the Ramsaytown-Knoxdale region reveal a considerable thickness of brownish sandstone above the Upper Freeport. The thickness ranges from very thin beds to as much as 165 feet of sandstone. In some holes the sandstone appears to be in two or three divisions separated by shale. In others, it is all sandstone. In several records, the sandstone cuts out the Upper Freeport coal and extends down through the horizon of the Butler sandstone of the Allegheny group. In drill hole number 37 of the Shawmut Mining Company on the George Smail farm in Knox Township about 1½ miles south of Ramsaytown, the base of this sandstone lies 196 feet above the Vanport limestone and extends 150 feet above that. It, therefore, occupies the lower 100 feet of the Conemaugh and the upper 50 feet of the Allegheny.

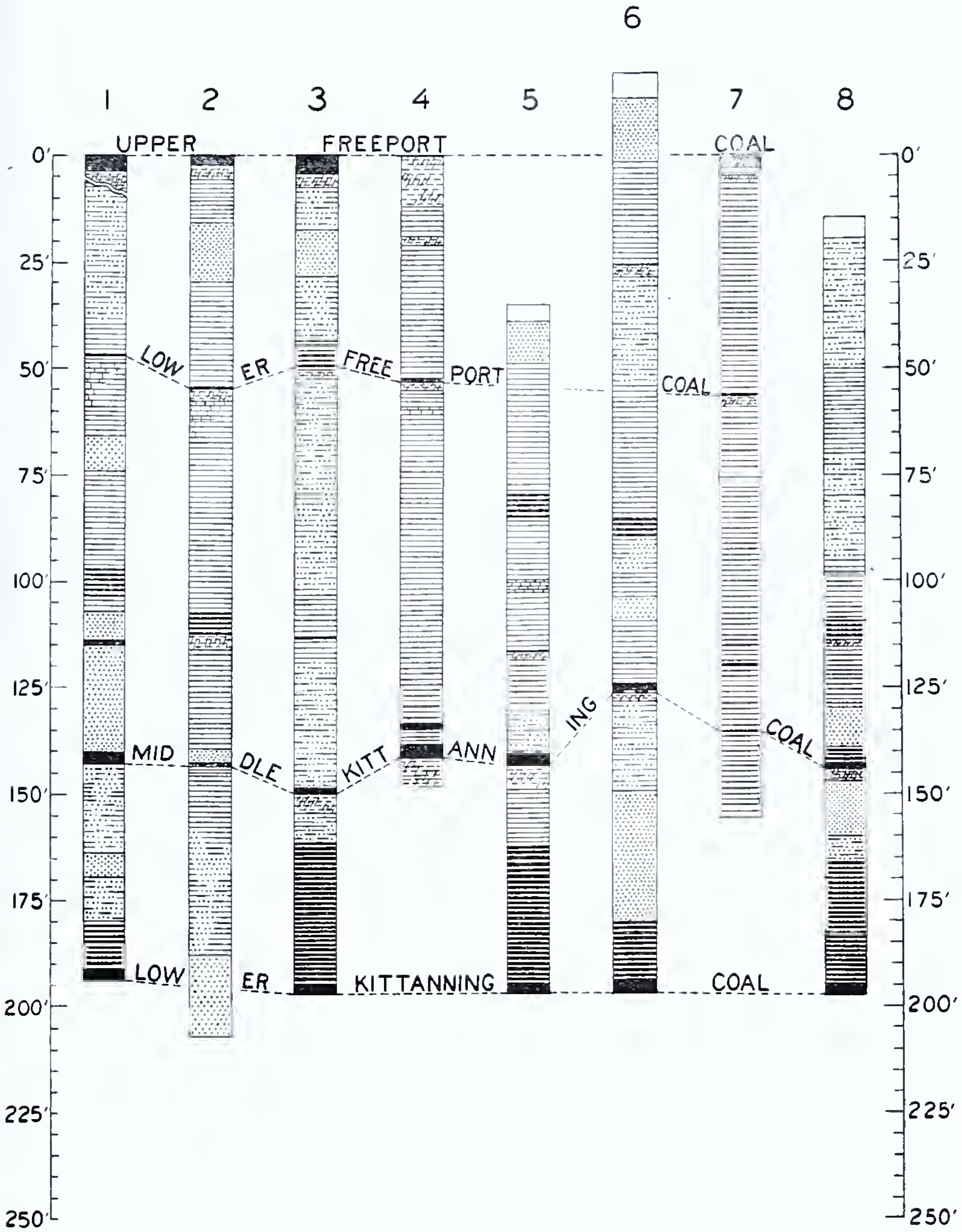
It is unfortunate that there are no good surface exposures of the Mahoning sandstone. The road and field exposures reveal only broken weathered fragments which give little indication of its character when fresh. It appears to weather into rather thin or slabby brown and buff fragments and gives little indication of real massive character.

Farther south in Ringgold Township in a high hill about one mile southwest of Worthville, a conglomeratic sandstone about 35 feet thick occurs in the horizon of the Upper Mahoning member. This observation is again based solely on float observed in the fields.

ALLEGHENY GROUP

The Allegheny group is so named because of its splendid exposure along the Allegheny River. It was formerly called the "Lower Productive Coal Measures" on account of the minable coal beds it contains. It is composed of sandstones, shales, limestones, clays, and coal beds, aggregating 325 feet in thickness. Economically it is the most important formation exposed in the quadrangle. Coarse and massive sandstone is much less prominent than in the underlying Pottsville. The shale is characteristically drab when fresh, but weathered exposures are usually brownish. Greenish shales become more common in the upper part.

The Allegheny group includes all the rock between the top of the Upper Freeport coal and the base of the clay under the Brookville coal. In areal extent the Allegheny group occupies nearly the entire quadrangle. In the deep valleys of the major streams, erosion has removed the Allegheny, exposing the underlying formations. The outcrop of this formation occupies a far larger area than any other in the region. It is much more uniform in thickness than would be expected from the variations of its members. The interval from the Upper Freeport coal to the Lower Kittanning coal is rather uniformly about 195 feet and that from the Lower Kittanning coal to the Brookville coal is generally about 130 feet. It is impossible to compile a columnar section of the Allegheny group which will apply over the whole area because the succession of strata varies considerably, as can be seen by a study of the sections given in figures 8, 9, and 10. However, certain beds are persistent over large areas and are therefore



Fige 8. Sections from drill records of the Shawmut Mining Company, showing the character of the strata between the Upper Freeport coal and the Lower Kittanning coal in Knox Township.

1. Hole No. 27. Swabb-Reitz farm.
2. Hole No. 24. Reitz farm.
3. Hole No. 58. C. Morrison farm.
4. Hole No. 2. H. D. Morrison farm.
5. Hole No. 72. Minich farm.
6. Hole No. 55. Borland farm.
7. Hole No. 5. Kitchen farm.
8. Hole No. 75. Ramsay tipple.

valuable key horizons in unraveling the Allegheny succession. Of these, the Vanport limestone is most valuable where present, because it is readily recognized as the only fossiliferous limestone in the Allegheny group. The Upper Freeport, Lower Kittanning, and Brookville coals are also recognizable over considerable areas. Thus, it is usually possible to determine the position of an outcrop as so many feet above or below one of these key horizons and thus determine its position and identification in the group.

The sandstone members are especially variable in their occurrence. They appear and disappear from hill to hill, often being replaced by shale. The lithologic similarity between the sandstones further complicates identification. Consequently, determinations based on the sandstones are not very reliable. Within the shale members comparatively thin sandstone layers are common, and in places these become sandstone lenses of considerable thickness. They are frequently cross-bedded and seldom massive.

The Allegheny group is the principal coal-bearing group of this region. Seven coal horizons have been definitely recognized and each has been named from some locality where the coal is prominent. These seven coal beds, or horizons, in their order from top to bottom are: Upper Freeport, Lower Freeport, Upper Kittanning, Middle Kittanning, Lower Kittanning, Clarion, Brookville.

The coal beds are variable in thickness and character. Some of them, such as the Lower Freeport and Upper Kittanning, are rarely thick enough to mine anywhere in the quadrangle. Others are uniformly persistent, such as the Upper Freeport and Lower Kittanning, and are usually of minable thickness. The Clarion and Brookville are rather erratic, ranging in thickness from a thin film to six feet in the case of the Brookville coal.

The Allegheny group has been divided into three formations: the Freeport, extending from the top of the Upper Freeport coal to the top of the Upper Kittanning coal; the Kittanning, extending from the top of the Upper Kittanning coal to the base of the clay under the Lower Kittanning coal; and the Clarion, extending from the base of the Kittanning formation to the bottom of the clay under the Brookville coal.

Freeport formation

Upper Freeport coal. The Upper Freeport coal marks the top of the Allegheny group and is therefore an important horizon stratigraphically. It is unfortunate that in the Ramsaytown-Knoxdale field where this horizon has been most actively mined and prospected, and where the information on this horizon is most available in outcrop and drill record data, there is doubt concerning the proper designation of the Upper Freeport horizon. In this region, a coal bed ranging from a few inches to six feet in thickness, and averaging four feet, has been mined on an extensive scale by the Shawmut Mining Company and various smaller companies. The region has been thoroughly drilled and enough data have accumulated to indicate that the same bed has been worked in each case. It has been traced from Knoxdale southwest to Worthville. The Second Pennsylvania

Geological Survey of Jefferson County by Platt undoubtedly considered this the Lower Freeport coal. It was called the Lower Freeport coal by the Shawmut Mining Company and other operators in the field. Sisler[1] refers to this coal as Lower Freeport, probably following the usage of the mining companies. The author was unable to ascertain from the engineers of the Shawmut Company their reason for calling it Lower Freeport. In the Punxsutawney district, a few miles southeast of the Brookville quadrangle, both the Upper and Lower Freeport coals occur and are mined, but the Lower Freeport coal is the more important. The interval between them is given by Ashley as 30 to 40 feet. It may be that the operators simply followed the determination of the Second Survey or assumed that the thick coal in the Ramsaytown-Knoxdale field was the same as the thick coal at Punxsutawney.

Over 100 drill records in the Ramsaytown region were obtained from the Shawmut Mining Company and plotted to scale. Some of these are shown on the accompanying figures. These records extend from Knoxdale to a point two miles southwest of Ramysaytown, about six square miles in area. Of all these records, not one reveals more than one thick coal in the Freeport horizon. This is undoubtedly always the same coal. Some records reveal only a few inches of coal, and in a few no coal at all is recorded. In nearly all the records, this coal is overlain by a great thickness of sandstone; in some places as much as 165 feet. This great thickness of sandstone is also evident from observations in the field. In the mines, a massive sandstone often forms the roof. The sandstone frequently thickens at the expense of the coal and in some places cuts out the coal completely. In several records, this sandstone apparently cuts out the coal and extends down at least 50 feet farther. In one case, the base of the sandstone is 194 feet above the Vanport limestone, whereas the interval between the Vanport limestone and the coal under discussion is rather uniformly about 240 feet. Further, not one of these drill holes has revealed any coal at an interval above this thick coal at which the Upper Freeport coal would be expected, assuming that the thick coal were Lower Freeport. If this coal is assumed to be Lower Freeport, then the overlying sandstone must have completely replaced the Upper Freeport horizon over a considerable area and in places even extended down 50 feet below the Lower Freeport. It seems more reasonable to regard this sandstone as the Mahoning sandstone which has in places filled old erosion channels cutting out the Upper Freeport coal. Furthermore, observations in adjoining areas indicate that the Upper Freeport coal is generally more persistent than the Lower Freeport.

The intervals between this coal and the Lower Kittanning coal and Vanport limestone in the Ramsaytown district are 195 and 240 feet respectively. These intervals are much the same as those given in adjoining areas as shown in the table below:

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[1] Sisler, J. D., Bituminous Coal Fields of Pennsylvania: Pa. Topog. and Geol. Survey, Bull. M. 6, Part II, p. 321, 1932.

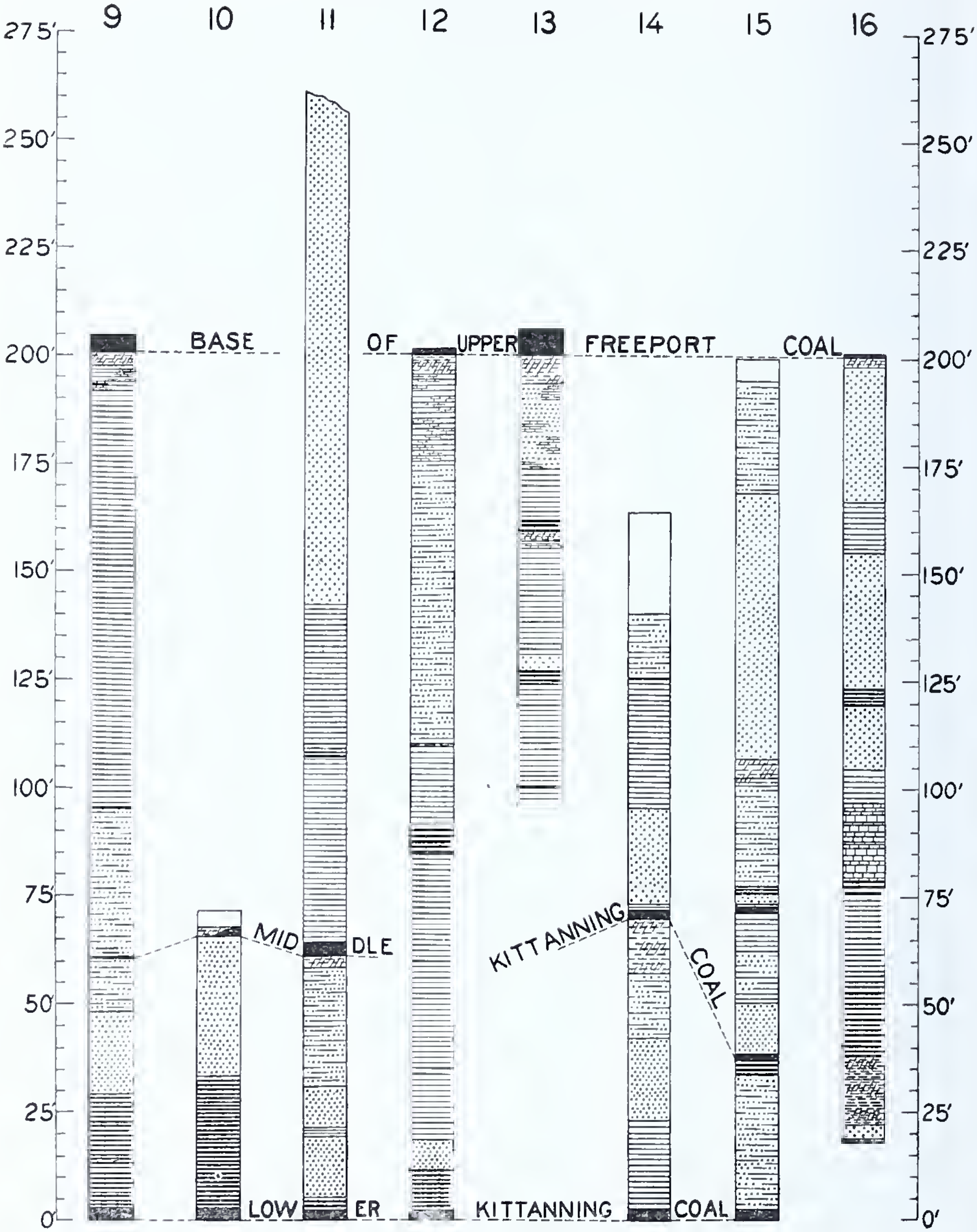

Figure 9. **Sections from drill records showing the character of the strata between the Upper Freeport coal and the Lower Kittanning coal in Knox and Oliver Townships.**

9. Shawmut Mining Company, No. 49. Millen farm, Oliver Township.
10. Shawmut Mining Company, No. 57. Thompson farm, Knox Township.
11. Shawmut Mining Company, No. 37. Smail farm, Knox Township.
12. Shawmut Mining Company, No. 50. Millen farm, Oliver Township.
13. Shawmut Mining Company, No. 10. Henderson farm, Oliver Township.
14. Atlantic Coal Company, No. 1. East Branch, Oliver Township.
15. Atlantic Coal Company, No. 2. East Branch, Oliver Township.
16. G. H. Hines, No. 3. Oliver Township.

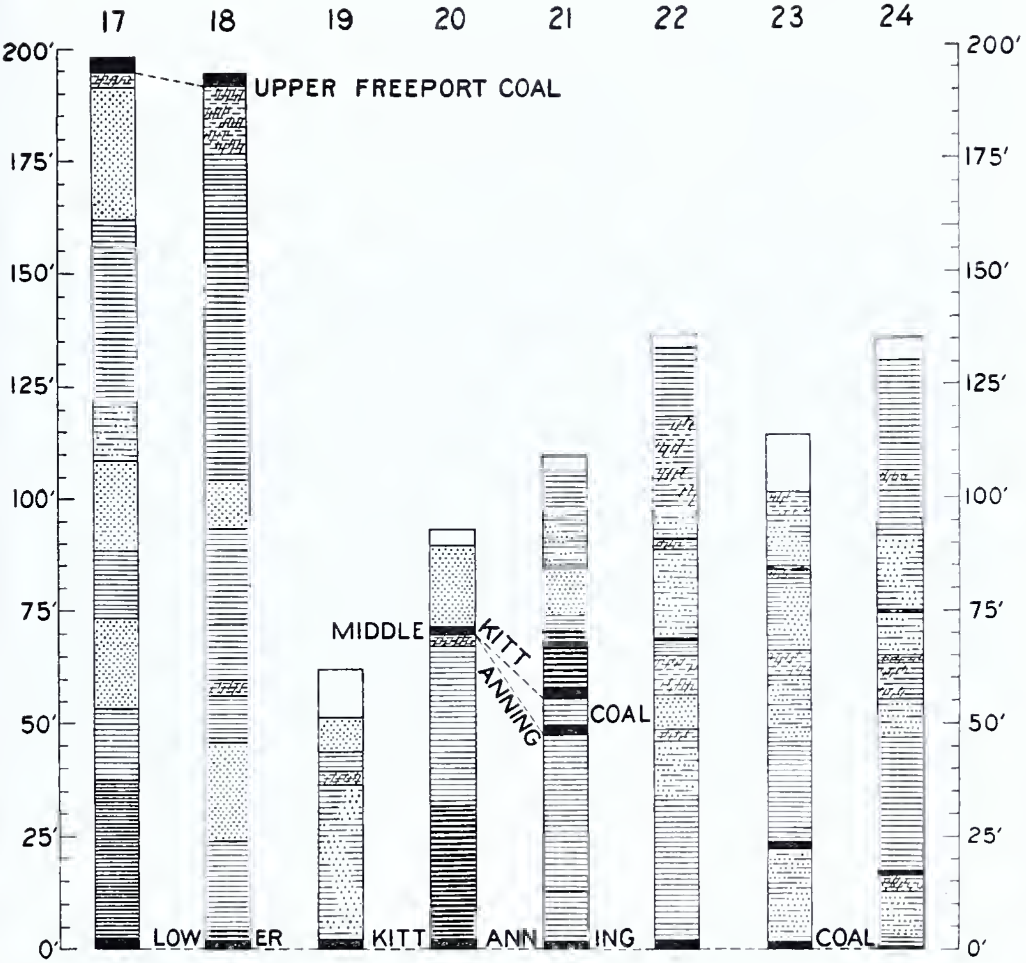

Figure 10. Sections from drill records showing the character of the strata between the Upper Freeport coal and the Lower Kittanning coal in Beaver, Rose, and Clover Townships.

Sections 17-21, Allegheny River Mining Co.; sections 22-24, Hanley Ceramics Co.

17. Hole No. 116. Jonathan Reitz farm, Beaver Township.
18. Hole No. 117. Jonathan Reitz farm, Beaver Township.
19. Hole No. 149. Rankin farm, Beaver Township.
20. Hole No. 97. Jonathan Reitz farm, Beaver Township.
21. Hole No. 137. Gil Reitz farm, Rose Township.
22. Hole No. 4. McLaughlin farm, Clover Township.
23. Hole No. 2. Carrier farm, Clover Township.
24. Hole No. 7. Guthrie farm, Clover Township.

Intervals from Upper Freeport coal

	Southern[1] Foxburg quad.	Clarion[1] quad.	Allegheny[2] Valley	Punxsutawney[3]	Brockwayville[4]	Ramysaytown
Lower Kittanning .	214	205		190-205	197	194
Vanport	245	240	250		237	240

[1] Geol. Atlas of U.S., U.S.G.S., Foxburg-Clarion folio (no. 178), 1911.
[2] Geol. Atlas of U.S., U.S.G.S., Rural Valley folio (no. 125), 1905.
[3] Pa. Topo. and Geol. Survey, Atlas of Pa., no. 65, Punxsutawney Quadrangle, 1926.
[4] Second Geol. Survey of Pa., Jefferson County, vol. H6, p. 186, 1881.

In the vicinity of Millen School, about 1½ miles southwest of Ramsaytown, some of the records reveal limestone about 30 feet and 60 feet respectively above the coal. Farther south, around Worthville, limestone was observed in the field in many places about 50 feet above this same coal. This was called the Upper Freeport limestone by Platt in his survey of Jefferson County[1]. A similar occurrence of limestones above the Upper Freeport coal is reported in the Punxsutawney quadrangle by Ashley[2]. These limestones have been regarded as in the Conemaugh in this report. Numerous inquiries of farmers who had dug into this limestone failed to reveal the presence of a coal comparable to the Upper Freeport associated with this limestone.

Many of the drill records show a thin coal, ranging from a few inches to one foot in thickness, at an average interval of 47 feet below the thick coal. This is regarded as the Lower Freeport coal in this report.

For the reasons outlined above, the thick coal that is mined in the Ramsaytown-Knoxdale area is called the Upper Freeport. The character of the coal will be discussed in more detail in the section devoted to coal.

Upper Freeport clay. The drill records in the Ramsaytown region indicate the presence of from 1 to 15 feet of clay directly under the Upper Freeport coal. The average thickness seems to be about 4 or 5 feet. This clay has not been worked in the quadrangle and so far as known no tests have been made of its quality.

Upper Freeport limestone. In many places in western Pennsylvania, limestone occurs below the Upper Freeport coal. Several drill records report "lime and shale" below the fire clay. About half a mile north of Tait on the Herriger farm, 3½ feet of limestone was observed in a small drift opened by Mr. Herriger. It occurs at an elevation of about 1,640 feet and is overlain by clay and thin coal. It appears to be the Upper Freeport horizon. The following section was obtained:

	Ft.	in.
Massive sandstone	10	
Coal	1	6
Fire clay	3	
Limestone	3	6

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[1] Platt, W. G., Report of progress in Jefferson County: Second Geol. Survey of Pa., vol. H6, 1881.

[2] Ashley, G. H., Punxsutawney quadrangle: Pa. Topo. and Geol. Survey, Atlas no. 65, p. 21, 1906.

Near the southern boundary of the quadrangle in Ringgold Township and also in Redbank Township, Armstrong County, about three feet of limestone occurs below a coal which is believed to be the Upper Freeport coal. The so-called "summit lime" in the Worthville region, which Platt called the Upper Freeport limestone, is now believed to be a limestone in the Conemaugh group and therefore above the Upper Freeport. (See fig. 11.)

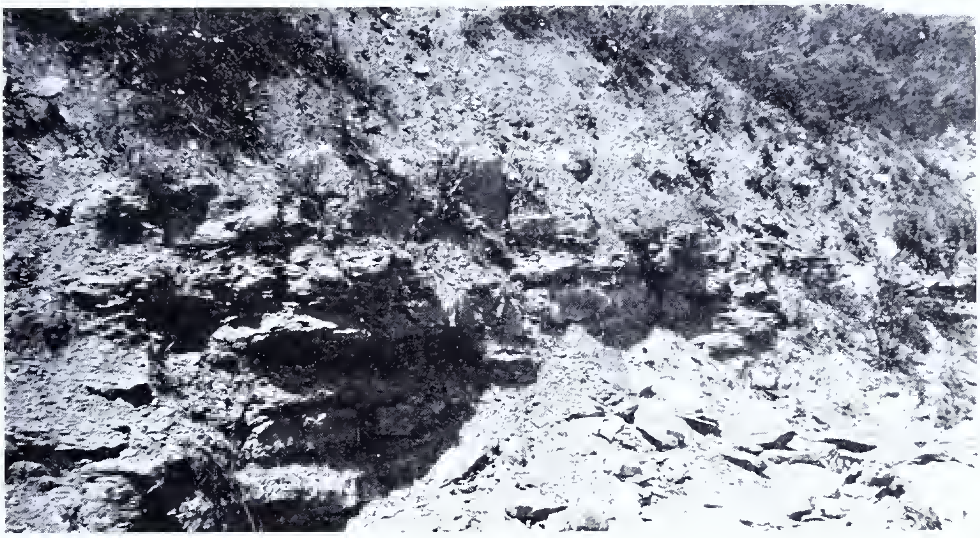

Figure 11. Small pit in limestone (Upper Freeport ?), Shaffer farm, one mile west of Worthville.

Butler sandstone. Sandstone and shale occupy the rest of the interval between the Upper and Lower Freeport coal. The sandstone varies considerably in thickness, for in some places it is lacking, elsewhere only a few feet in thickness, or it may reach a thickness of 20 to 30 feet. This sandstone has been called the Butler sandstone because of its fine development near Butler. There are no good exposures of this sandstone in the quadrangle, but drill records indicate its presence in many places.

Lower Freeport coal. Many of the drill records in the Ramsaytown district show a coal ranging from a few inches to one foot in thickness at an average interval of 47 feet below the Upper Freeport coal. It does not reach minable thickness in this district and was not seen in outcrop. It is underlain by fire clay with a maximum thickness of 6 feet which has not been worked or tested so far as known. Several of the drill holes in the Ramsaytown district encountered from 2 to 4 feet of limestone under the clay. This is the Lower Freeport limestone.

In the extreme southeastern corner of the quadrangle the hilltops carry a coal bed from 4 to 5 feet thick which has been mined in small country banks. This coal is believed to be the Lower Freeport for it seems to be the same as the Lower Freeport at Anita. About one mile farther east it is overlain by a thinner coal bed approximately 50 feet above it. At Charles Wolford's farm near the road intersection indicated as 1,631 feet in elevation, a 3- to 4-foot coal was struck at about 1,625 feet. This must be the Upper Kittanning coal, for it is about 55 feet below the Lower Freeport. A little farther north, in the hollow of Clutch Run, coal was dug at about 1,530 feet. This is probably Lower Kittanning.

The Lower Freeport coal was observed in outcrop in several of the higher hills west of Summerville. The best exposure is in the road cut along the New Bethlehem highway near the top of the hill just west of Summerville where the following section was obtained.

	Ft.	in.
Green shaly sandstone	20	
Carbonaceous shale	1	
Coal	0	8
Clay	3	
Limestone	2	
Green sandy shale	—	

About 50 feet above is a coal bed, found only in the hilltops, which ranges from 4 to 7 feet in thickness and which has locally been called the Lower Freeport. The interval to the Lower Kittanning averages about 180 feet, both at Summerville and at Bully Hill School, and the coal has been mapped as the Upper Freeport coal.

Freeport sandstone. The interval between the Lower Freeport and the Upper Kittanning horizon contains sandstone and shale. The sandstone ranges from a few feet to as much as 30 feet in thickness and does not seem to be the prominent feature of the section that it is in the Freeport region. Although it is not well exposed in the Brookville quadrangle, judging from its float, it appears to vary from flaggy fine-grained sandstone and sandy shale to coarse, massive beds which are locally conglomeratic. It is best exposed in the Pittsburg & Shawmut Railroad cuts at Tait where it is quite massive and crossbedded and about 30 feet thick. Fragments of conglomerate were observed in the fields in many places and at first believed to be Mahoning, but careful leveling seemed to indicate that the conglomerate was derived from the horizon of the Freeport sandstone. This is believed to be the source of the conglomerate boulders so numerous in the hills about 1½ miles north of Baxter. Unfortunately, the conglomerate was not observed in place.

The base of the Freeport formation is the top of the Upper Kittanning coal. The Upper Kittanning coal is not of minable thickness anywhere in the quadrangle; in fact, there is some doubt as to its proper designation in the section. Drill records indicate the presence of two nonpersistent and very thin coals between the Lower Freeport coal and the Middle Kittanning coal. Frequently this horizon is marked only by black shale. The upper of the coals occurs about 75 feet and the lower one about 110 feet below the Upper Freeport. The lower coal is the more persistent and is regarded as the base of the Freeport formation in this report.

Kittanning formation

Upper Kittanning coal. As indicated above, the coal that occurs about 110 feet below the Upper Freeport probably represents the Upper Kittanning. It averages 85 feet above the Lower Kittanning coal. As shown by many drillings, it is thin and nonpersistent, rarely reaching one foot in thickness. The horizon is marked in many places by black shale. This coal has not been mined anywhere in the quadrangle and is rarely seen in outcrop. One drill record in the vicinity of East Branch shows 2 feet of coal 95 feet above the Lower Kittanning. This is the thickest recorded Upper Kittanning in the quadrangle. The Upper Kittanning coal is underlain by a thin bed of fire clay which has no apparent value. One drill record in the Ramsaytown field shows 3 feet of bastard limestone, 94 feet above the Lower Kittanning coal. Although no coal was found above it, this limestone probably represents the Johnstown limestone. No outcrop of this member was observed in the field.

Upper Kittanning sandstone. The interval between the Upper Kittanning and Middle Kittanning coals contains shale, shaly sandstone, and sandstone. In the Ramsaytown field, this horizon is predominantly sandy, as much as 30 feet of sandstone occurring in the interval. In the Summerville region, the horizon is dominantly shaly. The sandstone is not well exposed anywhere in the quadrangle, but judging from fragments in the fields and road banks, it has no distinguishing characteristics which would differentiate it from the other sandstones in the Allegheny group.

Middle Kittanning coal. The Middle Kittanning coal is exceedingly variable in thickness and persistency. It was mined during the war in 1917-18 and the boom years following the war, along the valley of Indiancamp Run from East Branch to Knoxdale Station and was sometimes confused with the Lower Freeport. None of these mines are operating at present. It was also mined in the vicinity of Stanton. It crops out at many places in the quadrangle but, except for the areas mentioned above, it is generally too thin or inferior in quality for commercial development.

The following average intervals in feet above the Lower Kittanning coal were obtained from drill records: Ramsaytown 55, East Branch 70, Conifer 58, Sutton 50, Summerville 50.

Frequently the Middle Kittanning coal is split into two beds separated by shale. These splits are up to 6 feet apart.

This horizon is exposed in the Pittsburg & Shawmut Railroad cut one mile south of Knoxdale where the following section was obtained:

	Ft.
Sandstone, massive, cross-bedded, olive	20
Sandy shale	2
Black shale	7
Concealed, level of track	4
Coal—caved coal bank—drift goes just under track	

The Middle Kittanning horizon is exposed about one mile northeast of Baxter at the Clover-Rose Township line in a deep road cut made for the highway from Brookville to Summerville (fig. 12). The section exposed here is quite variable due to a lens of sandstone which comes in below the coal at the east end of the cut. The coal bends up over this sandstone lens. The coal is in two layers separated by about 8 inches of shale. The upper layer is one foot thick and the lower layer averages about 2 feet. At the west end of the cut the lower layer is again split into an 8-inch bed of coal separated by 6 inches of shale from the lower main bed, which is about 18 inches thick. Above the coal, and resting on it, are about 15 to 20 feet of thin-bedded sandstone. The bottom of the cut reveals 15 feet of black shale overlying the Lower Kittanning coal, which is at the level of the road foundation. The interval here between the Lower Kittanning and Middle Kittanning is unusually small, about 25 feet. The Middle Kittanning coal was once dug in a small country drift around the hill to the north and was said to be inferior in quality, mainly bony coal and slate. Here the interval to the Lower Kittanning, which was opened below it, is approximately 40 feet.

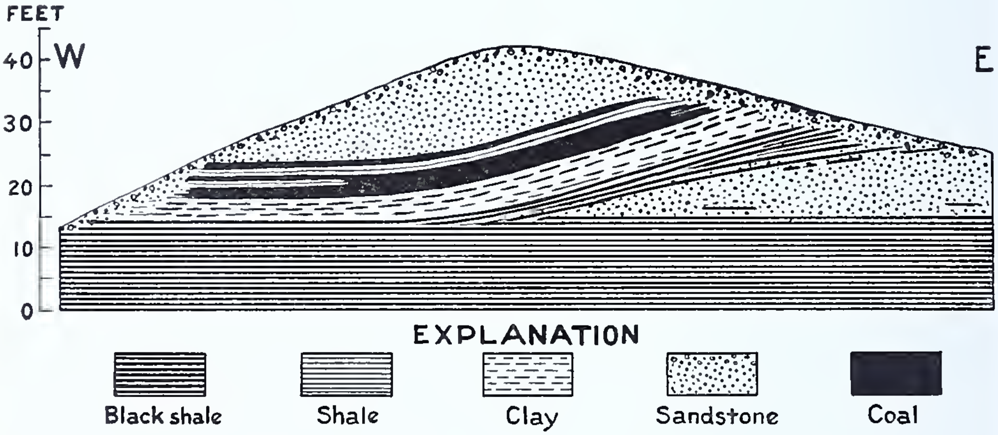

Figure 12. Diagram illustrating exposure of Middle Kittanning coal in the highway cut one mile north of Baxter.

Note the splitting of the coal and its concealment at the crop by hillside slumping. Also the variability of the coal measures is shown by the sudden appearance of the sandstone lens in the east end of the cut.

This exposure illustrates a condition that is very characteristic of the Coal Measures, namely the extreme variability of the rock succession even in a very restricted area. It also shows how as much as 3 feet of coal may be completely concealed at the outcrop by the slumping of overlying beds.

The Middle Kittanning coal is underlain by plastic fire clay ranging from 2 to 12 feet in thickness. It averages about 4 to 6 feet in thickness and has not been worked in this quadrangle nor tested so far as known.

Middle Kittanning sandstone. The strata between the Middle Kittanning and Lower Kittanning coals consist of sandstone and shale. Characteristically, the upper part of the interval is sandy and the lower part is usually black shale, frequently very carbonaceous and fissile. The sandstone may be only a few thin beds interbedded in shale or it may attain a massive character and be as much as 30 feet thick. About 30 feet of fairly massive, cross-bedded, dense, gray, micaceous sandstone is exposed in the road cut near the top of the hill just south of Crate School.

The black shale that occupies the lower part of the interval is almost always observed above the Lower Kittanning coal. Occasionally it is missing and the coal is overlain by sandstone. This black shale is exposed at many places in the quadrangle but nowhere better than in the cliff along Little Sandy Creek at Worthville where it is 30 feet thick. This shale is also exposed in the De Haven Coal Company stripping operation at Corsica where from 12 to 25 feet of shale overlies the Lower Kittanning coal.

The following section above the Lower Kittanning coal was obtained along the road northeast of Holden in Limestone Township, Clarion County:

Section near Holden	Ft.	in.
Thin-bedded, reddish-brown, micaceous sandstone	20	
Thin coal blossom	0	2
Dark shale	20	0
Coal, Middle Kittanning	2	0
Clay	—	—
Shaly sandstone	20	0
Green, sandy shale	10	
Black shale, siderite nodules	40	
Lower Kittanning coal—caved coal bank	—	

Lower Kittanning coal. The Lower Kittanning coal bed is a regular and persistent member of the Allegheny group throughout the quadrangle. It is a good quality coal, although rarely thick enough to warrant mining on a commercial scale. It has been mined in many small drifts for local consumption. Most of the house coal now used in the region is obtained from country banks in the Lower Kittanning. It usually is about 2 to 3 feet thick although there are places where it is thinner and some places where it is thicker. It is so persistent in its thickness that it is frequently called the "30-inch vein." Sometimes it is called the "30-foot vein" referring to its position above the Vanport limestone. This is misleading for, more often than not, the interval is from 40 to 50 feet. The Lower Kittanning rolls considerably, sometimes as much as 25 feet. This rolling character is well exposed in the stripping operation at Corsica.

Its identification is positively established over most of the quadrangle. In the extreme northern part in Mill Creek, Eldred, and Warsaw Townships where the Vanport limestone is missing and where all the coals are thin, there is some doubt as to which may represent the Lower Kittanning. It is undoubtedly present here but is thin and of no commercial importance.

The Lower Kittanning attains its greatest development in the region between Summerville and Corsica; in the vicinity of Stanton and

Ramsaytown; along Indiancamp Run near East Branch; in Burkett Hollow near Markton; and in the region north of Roseville.

The Lower Kittanning coal is usually in one bed but several drill holes and some gopher hole prospecting indicate that occasionally there are two coal beds at this horizon, both thin and separated by a few feet of shale. On the east side of Indiancamp Run, two thin coals in the Lower Kittanning horizon were dug about 20 feet apart. The Middle Kittanning coal was once mined 60 feet higher at this place, and the Vanport limestone was encountered in a test hole at the tipple of Campbell No. 2 mine at an elevation which would place it definitely below the two Lower Kittanning coals. Whether one of these coals is a split off the other or a stray bed of local extent could not be ascertained.

Lower Kittanning clay. The fire clay immediately underlying the Lower Kittanning coal is utilized extensively in western Pennsylvania because it is usually a high grade plastic clay. In the Brookville quadrangle this clay ranges in thickness from a few feet to 20 feet. The upper 3 or 4 feet is plastic clay and the lower part is usually sandy and less desirable. Undoubtedly there is abundant clay at this horizon for future development in the quadrangle. At present it is being mined at Summerville by the Hanley Company and mixed with clay from the Clarion horizon for the manufacture of face brick.

Clarion formation

The Clarion formation includes the strata from the base of the Lower Kittanning clay to the base of the clay beneath the Brookville coal. (See figures 13-16.) The thickness ranges from 120 to 145 feet. Numerous drill holes and partial road sections give accurate data on the details of the section. The formation includes the Vanport limestone, the Upper and Lower Clarion coals, and the Brookville coal as persistent members throughout most of the quadrangle. In Knox Township and the northern part of the quadrangle the section is different due to the disappearance of the Vanport limestone. Here the Vanport horizon seems to be occupied by sandstone, and a satisfactory determination of the succession is more difficult to make. At Brookville, which should be the type locality for this part of the Allegheny group, the section does not appear normal because it contains several thin coal beds that are difficult to identify, and the Vanport limestone is missing. Therefore, the section in the vicinity of Conifer, which is about 6 miles southwest of Brookville, is taken as the type section for the quadrangle.

Lower Kittanning sandstone. The interval between the Lower Kittanning coal and the Vanport limestone consists of shale, sandy shale, and sandstone; where both the coal and limestone are present, the horizon consists mainly of greenish sandy shale, but lenses of sandstone may be present which rarely become massive. However, where the Vanport limestone is lacking, this horizon becomes quite sandy, and frequently massive sandstone occupies much of the interval between the Lower Kittanning coal and the Clarion coals. This is the case at Roseville where approximately 45 feet of sandstone is exposed in the road cuts along the Lakes-to-Sea Highway. The sandstone is best exposed in the Carrier cut of the New York Central Railroad at the east end of the viaduct over Welch Run where the following section was obtained:

Section in Carrier Cut, New York Central Railroad

	Ft.	in.
Concealed, sandstone fragments	10	
Sandstone	2	
Sandy shale	2	6
Carbonaceous shale, sandy	2	
Shaly sandstone	15	
Massive sandstone, coarse-grained, cross-bedded, friable, argillaceous, plant fossils	15	
Vanport limestone	5	

In the hills north of here along Welch Run the Vanport limestone has never been found and the horizon apparently consists of sandstone.

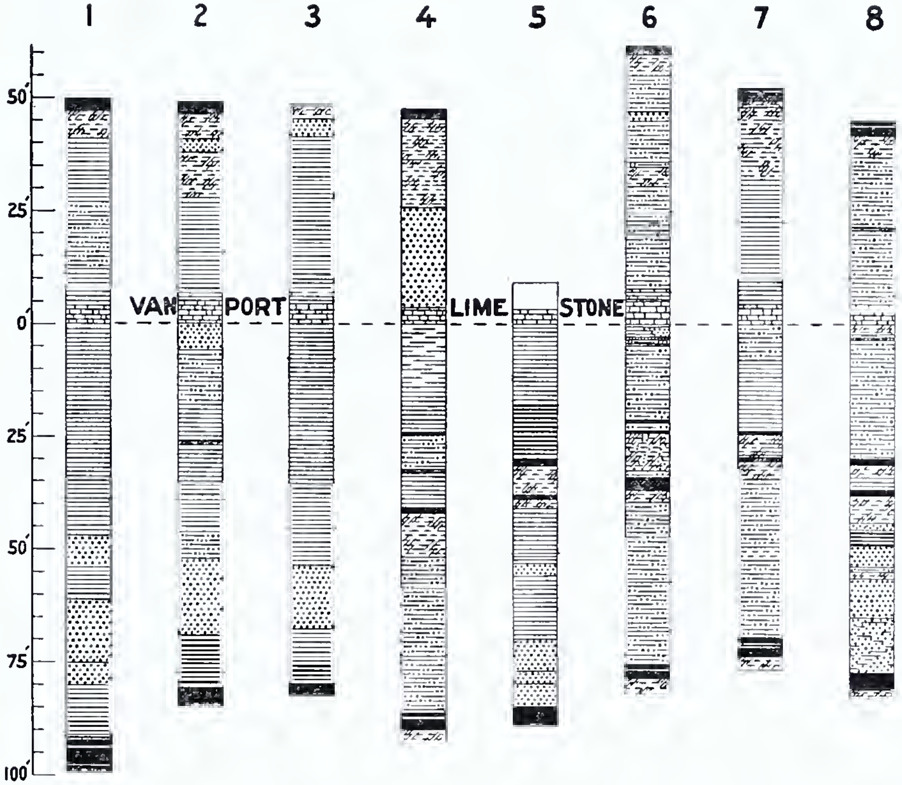

Figure 13. **Sections from drill records of the Allegheny River Mining Company, showing the character of the strata between the Lower Kittanning coal and the Brookville coal.**

1. Hole No. 116. Jonathan Reitz farm, Beaver Township.
2. Hole No. 97. Jonathan Reitz farm, Beaver Township.
3. Hole No. 117. Jonathan Reitz farm, Beaver Township.
4. Hole No. 145. F. P. Rankin farm, Beaver Township.
5. Hole No. 4. J. B. Shields farm, Clover Township.
6. Hole No. 149. F. B. Rankin farm, Rose Township.
7. Hole No. 137. Gil Reitz farm. Rose Township.
8. Hole No. 140. John Johns farm, Rose Township.

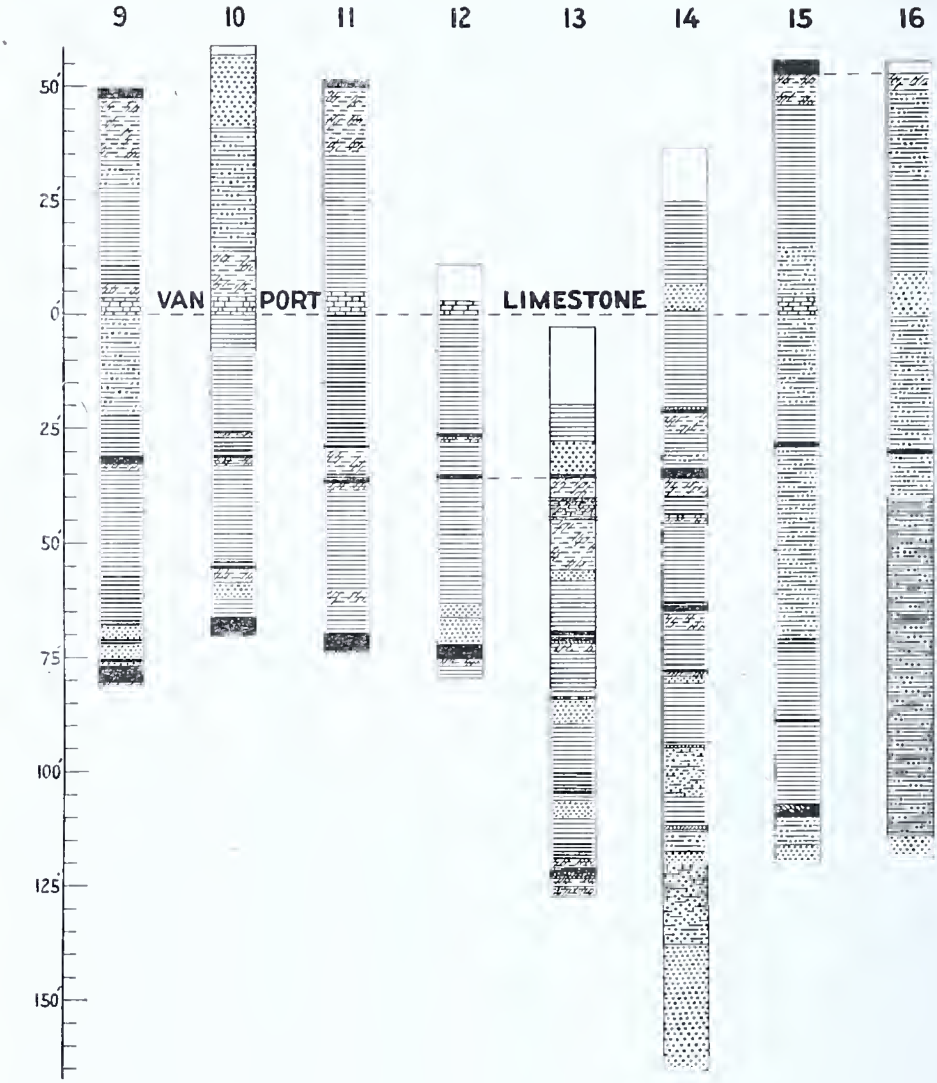

Figure 14. **Sections from drill records showing the character of the strata between the Lower Kittanning coal and the Brookville coal in Rose Township.**

Sections 9-14, Allegheny River Mining Co.; sections 15, 16, Shawmut Mining Co.

9. Hole No. 2. Thompson Abel farm.
10. Hole No. 3. George Abel farm.
11. Hole No. 47. George Barrett farm.
12. Hole No. 32. Smathers estate
13. Hole No. 130. Aaron Reitz farm.
14. Hole No. 131. Aaron Reitz farm.
15. Hole No. 60. Enoch McGary farm.
16. Hole No. 61. Enoch McGary farm.

Vanport limestone. The Vanport limestone lies from 30 to 50 feet below the Lower Kittanning coal and from 70 to 90 feet above the Brookville coal. It was formerly known throughout western Pennsylvania as the Ferriferous limestone because directly on top it often carries a bed of iron ore that is generally a hard, siliceous layer of impure siderite, limonite, or hematite ranging from a few inches to a foot or more in thickness. This is known as the "buhrstone ore" because it is often underlain by cherty material. Although this ore was once mined extensively when small furnaces were common in western Pennsylvania, it long ago ceased to be an economic source of iron. In accordance with modern geological nomenclature, the name Vanport was adopted because of the fine development of this limestone at Vanport on the Ohio River in Beaver County. Locally the farmers generally call it the "blue lime."

The Vanport limestone is a very persistent bed, usually about 5 feet thick in this quadrangle, and is exceedingly valuable as a key horizon in working out the geologic structure of the region as well as for the identification of other members of the Allegheny group, especially the coals, by measuring the interval above or below this limestone. It should be an important guide in drilling operations, for when its position is known the driller can estimate the depth to the gas sands. Unfortunately, in this region, either the drillers have not recognized it or have not recorded it on their logs, hence the most valuable key horizon of the region cannot be used in correlating the gas sands.

The Vanport is a bluish-gray limestone which generally runs over 90 percent calcium carbonate. It is very fossiliferous. Brachiopods and fragments of crinoid stems are abundant, and corals, pelecypods, and gastropods are common, all of which indicate that the Vanport is of marine origin. The limestone does not occur as a solid mass, but is broken both horizontally and vertically by joints which cause it to weather into large boulders under light cover.

The Vanport is present in most of the quadrangle, but is lacking in the northern part and in Knox and Pine Creek Townships east and north of Fivemile Run. Where it is lacking, the horizon appears to be mainly sandstone, sometimes quite thick and massive, which may be interpreted as an expanded Kittanning sandstone.

The Vanport is exposed in several of the cuts along the New York Central Railroad, notably at the Carrier cut near Ross School and at Sutton. It is present along Redbank Creek from the western margin of the quadrangle to Brookville. It is usually well up in the hills but at Summerville it is brought down by the Fairmount syncline to approximately 100 feet above the creek. At Brookville it is about 300 feet above the creek. It is present along Sugarcamp Run and in the high hill north of Alaska, but has not been observed northward. In the northwest part of the quadrangle its northern limit of occurrence is at Furnace School, which incidentally is near the site of an old furnace that utilized the limestone and its accompanying ore. The Vanport is found on the western side of the valley of Fivemile Run but not to the east. It lies near the hilltops where Little Sandy Creek empties into Redbank Creek but descends rapidly toward the Worthville syncline and passes below drainage level just west of Worthville. It rises again east of Worthville and is present in the hills eastward to East Branch. Lack of exposures and drilling in that densely wooded region leaves its presence in doubt. It extends northward along Indiancamp Run and passes below drainage level just north of Green Valley. The limestone is found along Mudlick Creek near drainage level and all along Big Run to Sprankle Mills but does not crop out in the intervening ravine of Cherry Run except near its mouth because it is taken below drainage level by the Worthville syncline.

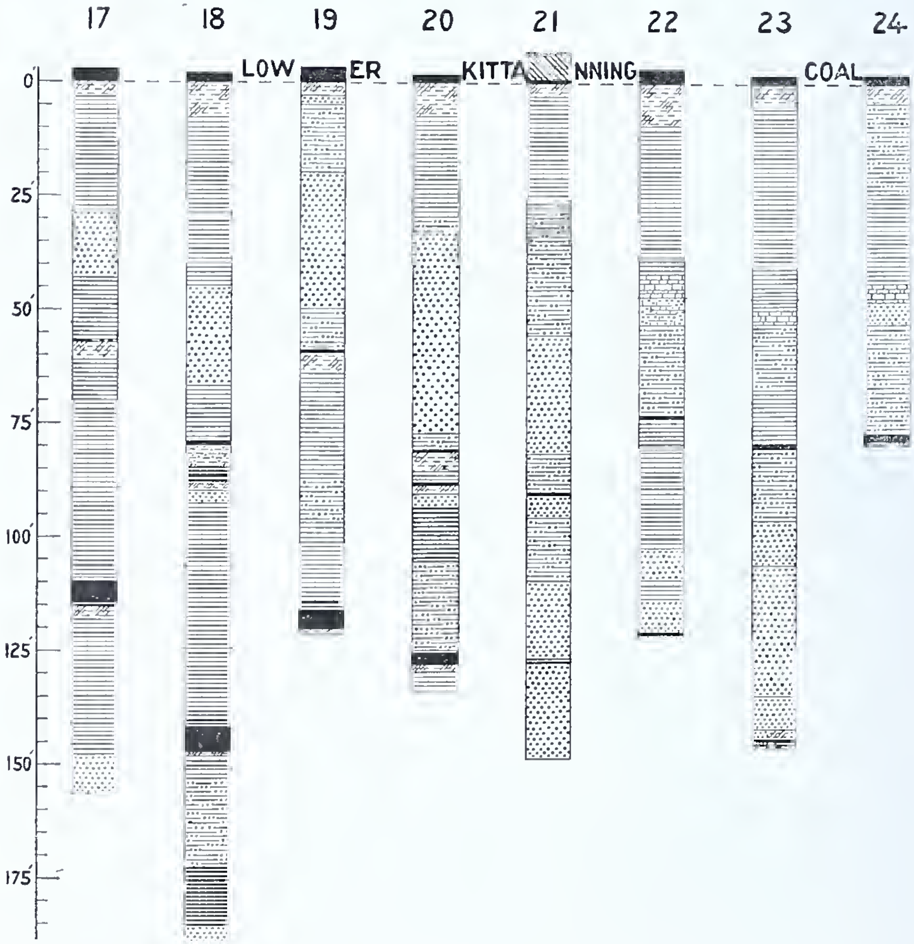

Figure 15. Sections from drill records of the Shawmut Mining Company, showing the character of the strata between the Lower Kittanning coal and the Brookville coal.

17. Hole No. 57. Jacob Thompson farm, Knox Township.
18. Hole No. 56. Jacob Thompson farm, Knox Township.
19. Hole No. 73. Jacob Thompson farm, Knox Township.
20. Hole No. 71. Butler and Campbell farm, Knox Township.
21. Hole No. 70. Teitrick farm, Knox Township.
22. Hole No. 52. T. T. Millen farm, Oliver Township.
23. Hole No. 82. Keller-Cochran farm, Knox Township.
24. Hole No. 59. Borland farm, Knox Township.

The following section was measured in the Pittsburg & Shawmut Railroad cut north of Coulter at the east end of the tunnel.

Section at east end railroad tunnel north of Coulter

	Ft.
Vanport limestone	5
Black carbonaceous shale, coaly	0¼
Shale	35
Sandstone and sandy shale	15

The sides of the cut are slumped and covered with shale fragments, but about the middle of the shale horizon are indications of clay and coal. This may be the Clarion coal.

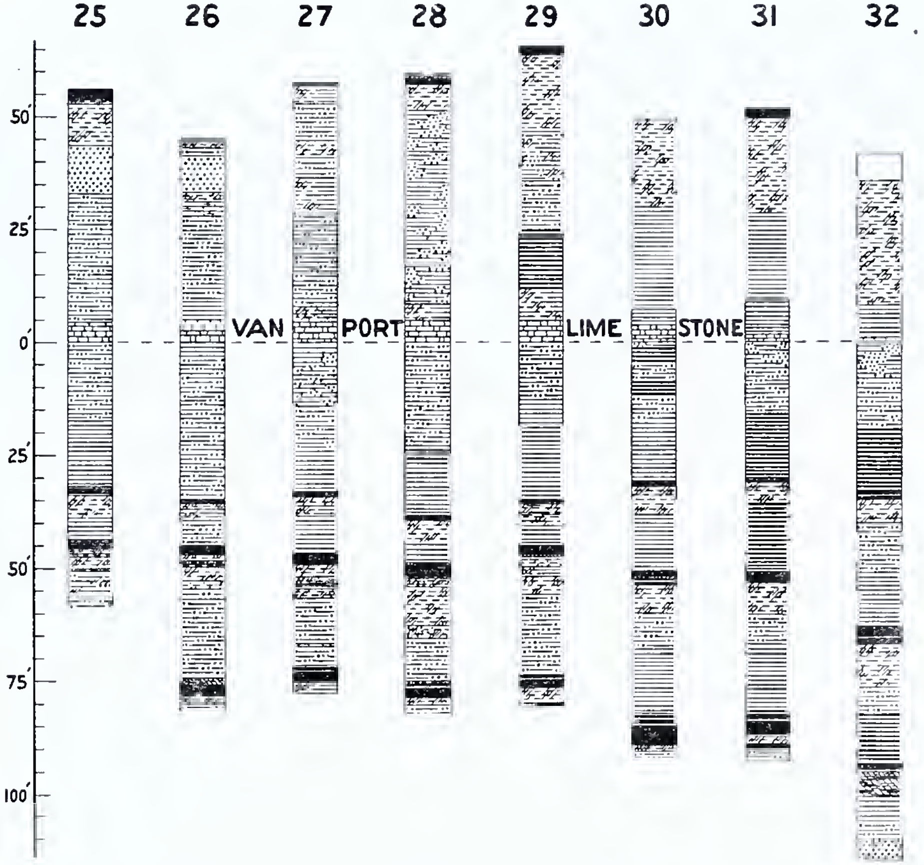

Figure 16. **Sections from drill records showing the character of the strata between the Lower Kittanning coal and the Brookville coal.**

Sections 25-29, Bradford B. & T.; sections 30-32, Klamath Mining Co.

25. Hole No. 4. McLaughlin farm, Clover Township.
26. Hole No. 7. Guthrie farm, Clover Township.
27. Hole No. 9. John Lane farm, Clover Township.
28. Hole No. 10. Wm. Plyler farm, Clover Township.
29. Hole No. 8. Wm. Plyler farm, Clover Township.
30. Hole No. 5. Elmer Cummings farm, Limestone Township.
31. Hole No. 4. Elmer Cummings farm, Limestone Township.
32. Hole No. 6. Elmer Cummings farm, Limestone Township.

The absence of the limestone in the northern part of the quadrangle and in most of Knox and Pine Creek Townships is probably due to nondeposition rather than that it was deposited and then eroded before succeeding sediments were laid down. (See fig. 17.) This conclusion agrees with Butts in his study of similar conditions in the Kittanning quadrangle[1]. The evidence in favor of the assumption that no limestone was deposited in the areas where it is now absent may be summarized as follows:

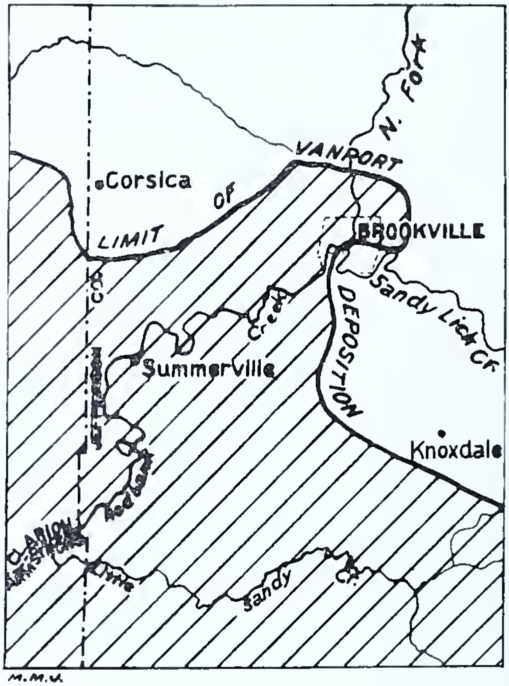

Figure 17. Diagram showing theoretical extent of Vanport deposition in the Brookville quadrangle.

1. The varied character of the Pennsylvanian strata in western Pennsylvania indicates that different kinds of sediments were deposited in different places contemporaneously. The local replacement of the limestone by shale or sandstone is in harmony with the general character of the stratigraphy of the region. It is not improbable that conditions were locally unfavorable to the growth of marine organisms from whose shells the calcareous sediment of the limestone was derived, or that conditions were unfavorable for the transportation of calcareous sediments from some source more or less removed and their accumulation in the places where the limestone is now absent.
2. The rounded, smooth outline of the areas in which the limestone is wanting resembles the shape of basins of deposition rather than areas of stream erosion or wave cutting.
3. Near the boundary of these areas the limestone is thinner and more sandy and the horizon is soon replaced by sandstone. This would indicate approach to near-shore conditions unfavorable for the accumulation and deposition of calcareous material.

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[1] Butts, Charles: Geologic Atlas of United States: U.S.G.S., folio 115, p. 7.

4. The limestone in large areas is a very thin stratum and it seems improbable that erosion would proceed in those places where it is absent just far enough to remove the limestone.

The Vanport horizon is indicated on the geologic map where its presence is known. It rarely appears in outcrop but there are numerous small pits where farmers from time to time have dug it for their own use or for local consumption (fig. 18). The geologic structure as shown in the accompanying map (pl. 3) is contoured on the Vanport limestone.

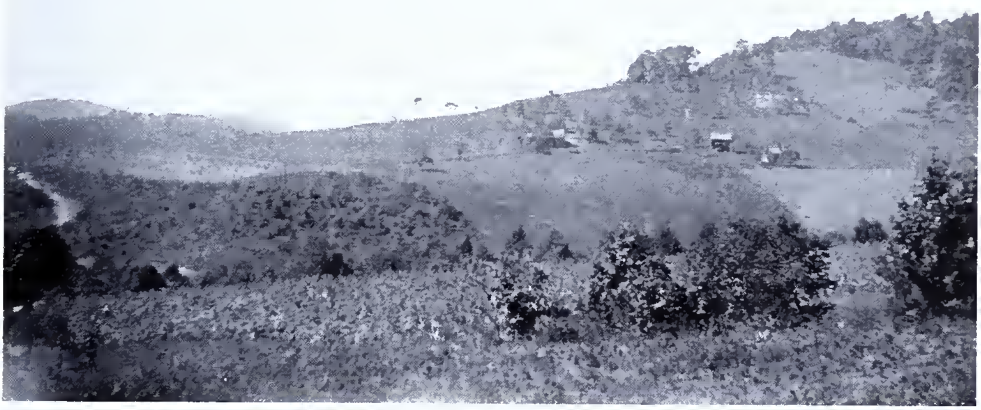

Figure 18. Topography at East Branch.
Shows Vanport limestone quarry above buildings at right.

Probably the most complete exposure of this horizon anywhere in the quadrangle is the bluff along Redbank Creek just south of Summerville where the following section was obtained:

Section in bluff south of Summerville

	Ft.	in.
Coal, Lower Kittanning	2	6
Concealed	20	
Shale, drab to brown	15	
Iron ore	0	3
Limestone, Vanport	5	
Sandstone, thin-bedded and interbedded shale	29	
Coal, Upper Clarion	0	8
Sandstone, shaly	14	
Coal, Lower Clarion	3	
Clay, plastic, grading to clay shale toward bottom	15	
Sandstone	1	
Shale, black, with bony partings and few siderite nodules	9	3
Coal, Brookville	0	9
Shale	1	
Sandstone, shaly	3	
Shale, clayey to sandy below; bony and irony at top	12	
Coal, Brookville	0	4
Sandstone, massive, cross-bedded, Homewood	8	
Creek level	—	
Total	139	9

The "Buhrstone ore," which is so often present as a thin bed immediately overlying the Vanport limestone, was interpreted by I. C. White[2] as formed by precipitation from downward-percolating iron-laden waters at the horizon of the Vanport limestone and contemporaneous with partial solution of the limestone. White implies a genetic relation between the ore and limestone. However, zones of siderite concretions often occur in areas where the Vanport limestone is lacking.

A section southwest of Milton in the adjoining Smicksburg quadrangle illustrates this:

	Ft.	in.
Shale, dark		
Coal, Lower Kittanning	2	4
Shale with iron nodules (Vanport horizon)	26	0
Sandstone	9	0
Coal and light, plastic fire clay, Scrubgrass		
Shale, dark	12	0
Coal, bony, Upper Clarion	2	1
Clay shale and sandy shale	10	
Shale, carbonaceous, Lower Clarion	0	3
Clay, greenish sandy	2	5
Shale, gray with siderite concretions and sandstone lenses	7	0
Sandstone, gray, Clarion	55	0

In these areas the ore bed or concretionary zone occupies the same stratigraphic position as the Vanport limestone and may be used as a key bed in the absence of the Vanport.

Most siderite ore beds are the result of secondary concentration. The uniform stratigraphic position of the ore bed, even where the Vanport is missing, suggests the possibility that the originally deposited sediments at this horizon may have had a high iron content which has later influenced the concentration of iron from percolating waters. If this is so, the relation between the Vanport limestone and the ore bed is none other than one of stratigraphic position.

Directly under the Vanport limestone a bed of black coaly shale several inches thick sometimes occurs. This would be about at the horizon of the Scrubgrass coal of Butler County. Normally the Vanport limestone lies on a thin bed of flaggy sandstone, rarely more than 5 feet thick, which the farmers call "shell rock," and which to them is a key in their search for the limestone. The rest of the interval to the Upper Clarion coal, which usually lies from 25 to 35 feet below the Vanport, consists of greenish shale and sandy shale.

Upper Clarion coal. The Upper Clarion coal has been regarded by many as an upper split of the Clarion coal. Locally, it is frequently referred to as the "marker" or the "pencil mark" coal. Although only 8 to 20 inches thick, it is remarkably persistent in the central part of the quadrangle and is best exposed in the New York Central Railroad cut at Sutton. It is never thick enough to mine, although occasionally farmers have dug it for their own use where it reached a thickness of 18 inches. The interval to the Lower Clarion ranges from a few feet to 20 feet and usually consists of plastic clay, clay shale, and black shale although, where the interval is large, the shale may become quite sandy. The variability of this interval is well exposed in the Hanley Company clay mines at Summerville. The Lower Clarion coal makes the roof of the clay and, where the interval above to the Upper Clarion coal is more than 5 or 6 feet, no difficulty is encountered with the roof, but where the interval is less, the roof comes down, exposing the Upper Clarion coal and sometimes the shale above, resulting in rooms of great height and necessitating extensive timbering.

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[2] White, I. C., The geology of Lawrence County: Report of progress QQ, Second Geol. Survey of Penna., 1877.

Lower Clarion coal. The Lower Clarion coal is usually the thicker of the two Clarion coals. It lies from 30 to 50 feet below the Vanport limestone and from 30 to 55 feet above the Brookville coal. Generally it is thin and poor in quality, for it contains considerable iron sulphide. Farmers often call it the "sulphur vein." It ranges in thickness from a few inches to 3½ feet. The Lower Clarion coal reaches its greatest development in the vicinity of Sutton and Holden, where it was formerly mined. It is no longer mined on a commercial scale and seldom dug for country trade on account of its high sulphur content. The horizon of the Clarion coals is excellently exposed in the New York Central Railroad cuts at Sutton and east of Sutton where the following sections were obtained:

Sections in New York Central RR cuts at Sutton

At Sutton	Ft.	in.
Sandstone	15	
Shale	5	
Limestone, Vanport	5	
Clay	2	
Shale	25	
Coal, Upper Clarion		10
Shale		1
Coal, Upper Clarion		10
Clay	4	
Sandy shale	10	

East of Sutton	Ft.	in.
Shaly sandstone	18	
Limestone, Vanport	4	
Clay	2	
Shale	20	
Coal, Upper Clarion	1	
Clay	3	
Shale	15	
Coal, Lower Clarion	2	6
Clay	8	

Still farther east, in the railroad cut on the west side of Simpson Run, this horizon is again well exposed and the section was obtained as follows:

	Ft.	in.
Shale, thin sandstone layers and lenses	25	
Coal, Upper Clarion	1	
Clay	4	
Shale	10	
Coal, Lower Clarion	3	3
Clay	2	+

In the southern part of the quadrangle this horizon is best exposed in the railroad cut at the west end of the tunnel north of Coulter where the following section was obtained:

Section at Coulter

	Ft.	in.
Interbedded sandstone and shale	10	
Carbonaceous shale and clay	5	
Sandstone	3	
Carbonaceous shale	5	
Shaly coal	1	6
Clay shale	8	
Coal (Clarion)	0	11
Carbonaceous shale	—	—

Clarion clay. The Lower Clarion coal is underlain by a bed of plastic clay which is best developed in the region between Summerville and Holden. The clay ranges from 4 to 10 feet in thickenss. It is mined by the Hanley Ceramics Company at Summerville for the manufacture of face brick. More detailed description of this clay will be given in the section on clays.

Clarion sandstone. Between the Clarion coals and the Brookville coal is the horizon of the Clarion sandstone. It is usually a brownish, cross-bedded, fine-grained, and thin-bedded sandstone ranging from 5 to 25 feet in thickness. It is not always present, in which case the horizon is shale or sandy shale. Frequently, the sandstone rests on the Brookville coal and often cuts out part or all of the coal. In some places the Clarion sandstone is massive and, where the Brookville coal is not well developed, is easily confused with the Homewood sandstone. Undoubtedly the ''mountain sand'' as reported in many of the gas well records of this region includes also the Clarion sandstone.

The Clarion sandstone is present in the vicinity of Conifer where it forms the roof of the Brookville coal and is exposed in the railroad cut above No. 1 mine. In the Pennsylvania Railroad cut, about 1 mile southwest of Coder, the Clarion sandstone appears massive and 25 feet thick and resembles the Homewood sandstone, the top of which also appears near the bottom of the cut.

Brookville coal. The Brookville coal lies at the base of the Allegheny group and therefore is stratigraphically important in separating the Allegheny from the underlying Pottsville series. This coal was named, as indicated by Rogers in his summary report of the First Geological Survey of Pennsylvania, for a coal mined around Brookville. He gives no specific location so that it is not known which coal bed at Brookville was the one to which the name was applied. Platt[1] specifically indicates two places in Brookville where he says the Brookville coal was mined. One is at the Newsome Pottery in Tunnel Hill. The other locality is given as along the road west from town toward Corsica ''where it makes a distinct bench, which curves gracefully round the point of the hill towards the southeast. An opening once made upon it here, close to the roadside, revealed only about 18 inches of coal. The Clarion seam, 1 foot thick, is exposed at the water trough.'' As indicated previously in this report, it seems more reasonable to regard the coal and clay at the Newsome Pottery as Clarion. There is a caved coal bank along the Lakes-to-Sea Highway in Brookville at the turn of the road near the garage and filling station at an elevation of 1,450 feet. This is probably the coal to which Platt refers and is probably the Lower Clarion coal. The 1-foot coal 30 feet above it is the Upper Clarion. The Vanport limestone has been dug in this hill at about 1,500 feet elevation.

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[1] Platt, W. G., op. cit. p. 106.

The Brookville coal is not well-developed in the immediate vicinity of Brookville. The vague correlations and interpretations of sections made near Brookville have been a source of confusion for many years, and different coal horizons near the town have been termed the "Brookville coal" at different times.

A careful study of six sections made at Old Humphrey quarry east of town, at New Humphrey quarry southeast of town, and at Tunnel Hill south of town remove all doubt as to the correct position of the Brookville coal. The coal is one foot thick where it crops in the wall of Old Humphrey quarry 28 feet above the floor (pl. 11, A). The Brookville coal was mined at one time at Tunnel Hill, and four caved drifts remain on the narrow spur of the hill just north of the forked roads and the schoolhouse at an elevation of 1,390 feet. In the wall of New Humphrey quarry a 1-foot coal crops 36 feet below the Clarion coal at the top of the quarry (pl. 11, B). This coal is at the position of the Brookville. These three sections are presented in figure 19.

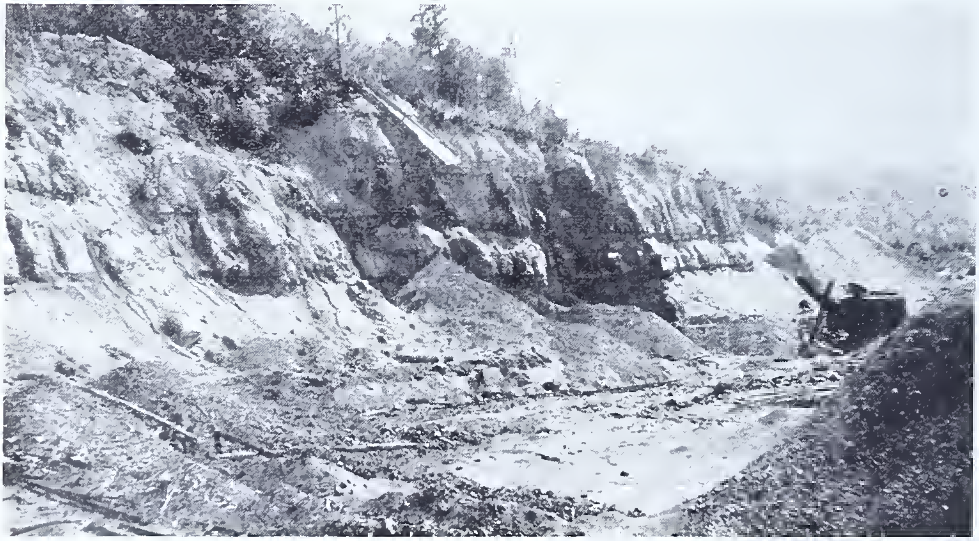
The variation in character and thickness of the strata composing the Upper Connoquenessing sandstone, the Mercer group, the Homewood sandstone and the Brookville horizon is striking. The sections in figure 19 show the Homewood sandstone disappearing in a short distance and an increased development of coal and shale. The Homewood is absent at New Humphrey quarry and well-developed at Tunnel Hill. The evident variation of these strata gives rise to the possibility that the so-called Mercer group and Brookville group are the same and have heretofore been made separate stratigraphic units only because an intervening sandstone (the Homewood) happened to be well developed in certain localities.

In this connection, the findings of Dr. David White, of the U. S. Geological Survey, on the flora of the black fissile shale from the floor of Old Humphrey quarry are significant:

> The plant debris is evidently very abundant in the floor of the Old Humphrey quarry, and the preservation is clear. Most of the fragments belong, however, to a very narrow-leaved early form of *Neuropteris hirsuta* which has, in later years, been included in *N. Scheuchzeri*. No large leaflets of the species are present, though its fragments are so abundant as to monopolize the field.
>
> Also present in the Humphrey quarry are small fragments of a species of *Pecopteris*, probably belonging to *P. miltoni, Brong.* These approach rather closely *P. pseudovestita.*
>
> Small fragments of *Cordaites* leaves, probably belonging to *C. communis* and fragments identifiable as *Calamites* are also present.
>
> The plants from the Old Humphrey quarry are in harmony with the youngest material found in the Mercer group. In fact the *Neuropteris* form is most at home there. On the other hand, the collection does not contain characteristic species of the Mercer group, especially the lower part of the group. The plant fragments associated with the fire clay in the quarry are present in greater variety, and I have been inclined to regard it as uppermost Mercer. Probably some of the species which favor Mercer age might be found if a larger collection were made in the floor of the quarry, although it would seem that we had at the time of deposition a thicket of one species of *Neuropteris.*

PLATE 11

A. Brookville coal horizon in Old Humphrey quarry, Brookville.



B. New Humphrey quarry, Brookville.
The Brookville coal is the top coal in the quarry face. Chute comes from level of Clarion coal and clay.

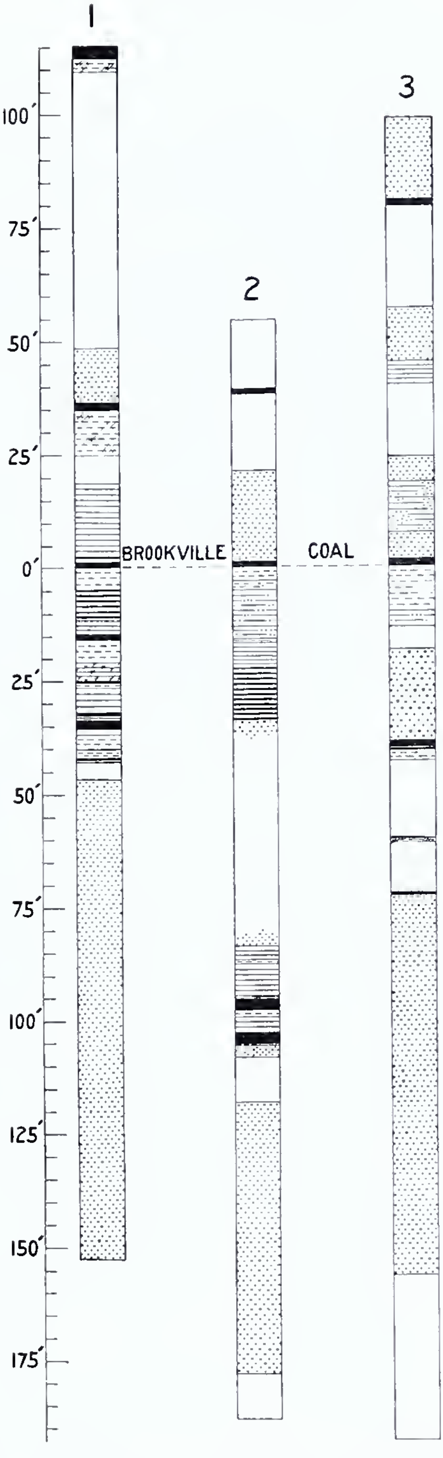


Figure 19. Sections showing the position of the Brookville coal and the variable character of the Mercer strata at Brookville.

1. New Humphrey quarry, one mile southeast of Brookville.
2. Old Humphrey quarry, one mile east of Brookville. Compiled from two sections.
3. Tunnel Hill, one mile south of Brookville. Compiled from three sections.

White's conclusions imply Upper Mercer age for the black shale. At another time[2], White remarked upon the impossibility of distinguishing the Mercer flora from the Brookville flora. His words may well be interpreted as implying the same age for both groups.

Sherrill[3] states that he has definitely traced the upper Mercer coal of eastern Mercer County into the Brookville coal in the Foxburg area, about 30 miles west of Brookville.

Whether the series of strata are to be considered as separate Brookville and Mercer groups or as a combined and expanded Brookville-Mercer group, the so-called Brookville coal is identifiable in the vicinity of Brookville. However, it has no commercial importance in this area. It seems best that the well-developed Brookville coal bed which is mined at Conifer should be the type coal for the quadrangle. It is unfortunate that the name Brookville is so firmly established from long usage that it cannot be changed to Conifer.

Along Smathers Run and near Conifer in Beaver and Rose Townships, the Brookville coal ranges from 3 to 5 feet. It has been extensively mined. In this region, the Vanport limestone, the Upper and Lower Clarion coals, and the Brookville coal are all normally developed in the section as revealed in outcrop and in numerous drill records. For this reason, this locality has been adopted as type Brookville for the quadrangle.

The Brookville coal is reported to be 4 feet thick two miles north of Brookville (one mile north of Alaska) where it has been mined along the Sigel road. It is the same bed that is mined 1¼ miles northeast at the Minewcaser mine.

In the Pennsylvania Railroad cut about one mile southwest of Coder is the best exposure of the Brookville coal in this area. It is overlain by massive Clarion sandstone and underlain by massive Homewood sandstone. The extreme variability of the Brookville coal is well shown by measurements in different parts of the cut.

Brookville coal in Pennsylvania Railroad cut, 1 mile southwest of Coder

West			Center			East		
	Ft.	in.		Ft.	in.		Ft.	in.
Massive sandstone	15		Massive sandstone	25		Massive sandstone	7	
Coal	2	6	Coal	0	8	Coal	1	6
Clay	1	8	Clay	0	4	Sandstone	0	3
Coal	1		Coal	0	1½	Coal	5	7
Bony coal	0	10	Clay	0	10	Clay and carbonaceous shale	2	6
Clay	2	6	Sandstone	1		Coal	3	
Sandy clay	3		Coal	4	6	Carbonaceous shale and bony coal	1	
Massive sandstone	15		Clay	2	6	Clay	4	5
			Coal	2	4	Massive sandstone	8	
			Clay	4				
			Massive sandstone	10				

In the northern part of the quadrangle the Brookville coal is generally thin or lacking where the Clarion and Homewood sandstones unite. It is present, however, along Mill Creek in Eldred Township in the vicinity of Caldwell School. It crops out in a small run tributary to Mill Creek on R. E. Park's farm about half a mile west of the Sigel road where it is 4 feet thick.

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[2] White, D., Personal communication to Dr. George H. Ashley, Sept. 1921.

[3] Sherrill, R. E., Personal communication to Dr. George H. Ashley, March 1941.

Near the hilltops in the vicinity of Richardsville, the Brookville coal is dug for house fuel. It is considerably split and inferior in quality.

Along Redbank Creek at Coder, the Brookville coal appears well up on the cliff banks and descends rather rapidly to Summerville, where it was mined just above creek level. Northward from Summerville it has been mined along Runaway Run to Sutton where it is 4½ feet thick and mined by shafting. The Brookville coal rises again below Summerville, and at Patton Station it is again near the hilltops. Along Little Sandy Creek it rapidly descends from the tops of the hills near Redbank Creek to below drainage level near the mouth of Ferguson Run. It is of minable thickness throughout Beaver Township.

The Brookville horizon is again above water between Cool Spring and East Branch but it makes no showing and the coal apparently is not well developed. Its horizon is above water level at Sprankle Mills but the coal was not observed.

Just west of the quadrangle along the highway to New Bethlehem, a new road cut near Mayport exposes this horizon. The following section was obtained, from top down: Dark shale 15 feet, coal 14 inches, clay 4 feet, massive, buff sandstone 20 feet.

The Brookville coal where it is typically developed in the central part of the quadrangle is characterized by a shale or sandstone parting several inches thick from 8 inches to 1 foot below the roof. About 4 inches below the parting is approximately 2 to 4 inches of hard cannel-like coal running 20 to 40 percent ash. The Brookville tends to run high in sulphur, which generally occurs in balls. The average interval between the Vanport limestone and the Brookville coal in various parts of the quadrangle is as follows, in feet: Conifer 79, Smathers Run 77, Summerville 77, Sutton 89, Pansy 84, Ramsaytown 90.

Usually the Brookville coal is underlain by 1 to 4 feet of clay. In many localities in western Pennsylvania clay is mined at this horizon. In the Brookville quadrangle this clay has been mined at only two places. The Humphrey Brick and Tile Co. formerly worked the 6-foot bed of clay which underlies the Brookville coal in Old Humphrey quarry, just east of the Brookville borough line. This company also used some of the clay from the 6-foot bed underlying the so-called Brookville coal in New Humphrey quarry. At the present time they are working the 8-foot bed of Lower Clarion clay at the top of New Humphrey quarry.

Attention should be directed here to the conclusion that the clay at the old Newsome Pottery which Platt called Brookville is probably Clarion. The clay exposed in the road bank at the school house in Tunnel Hill is, however, Brookville.

Pottsville Series

In general, the Pottsville series in this quadrangle consists of about 200 feet of rocks. The top of the series is the generally massive Homewood sandstone; the Mercer group of shales, coals, and clays lies below; and at the bottom is the massive Connoquenessing sandstone.

Farther west, in Mercer County, the Mercer horizon includes two limestones, but these were not observed in the Brookville quadrangle. Also in the west, the Sharon coal and sandstone come in below the Connoquenessing, but this member is apparently absent in the Brookville area.

The top of the Pottsville can usually be located by a massive sandstone that is generally found about 80 to 100 feet below the Vanport limestone. The difficulty in locating the exact top of the series lies in the fact that between this sandstone and the Brookville coal is a variable thickness of shale. Where the Brookville coal is thin or lacking, and the Clarion sandstone is well developed, confusion occurs between the Clarion and Homewood sandstones. This is especially true in the northern part of the quadrangle. Wherever possible, the top of the Pottsville is mapped in the Brookville quadrangle at the base of the clay under the Brookville coal. Where the coal is not determinable, the line is drawn at the top of the massive sandstone which seems most likely to be the Homewood.

The base of the Pottsville series cannot be recognized as such in this region. The Mauch Chunk formation has apparently been eroded. Work done in adjoining areas indicates that the top of the Pocono formation is also missing and that the Pottsville rocks rest unconformably on the Burgoon member of the Pocono. The line of separation is not lithologically clear, fossils are very scarce, and exposures in this horizon are very poor. Massive sandstones are found at the top of the Pocono and at the base of the Pottsville. These sandstones are very similar in all characteristics and cannot easily be distinguished. The sandstones of the Pottsville are in general thicker-bedded, slightly coarser, and more purely siliceous.

In adjacent areas the approximate thickness of the Pottsville is given as follows: Clarion quadrangle 120-130 feet, along Allegheny River 125-200 feet, Punxsutawney quadrangle 200 feet, Rural Valley quadrangle 140 feet.

The whole of the Pottsville series is certainly above drainage in the vicinity of Patton Station on Redbank Creek, brought up by the North Freedom anticline. Unfortunately rock exposures do not exist in this densely-wooded region. Sandstones are exposed in the cuts along the Pennsylvania Railroad between Heathville and Mayport, but fossils are fragmentary and nothing satisfactory could be determined regarding the age of these sandstones. North and south of Patton Station, sandstone is exposed in the cuts with some interbedded shale. Platt[4] states that he saw a small exposure of "red clay shale, without fossils, and only a few feet thick" in a railroad cut at Patton Station. He further said that it was "220 feet below the top of the Homewood sandstone, and therefore, is most probably a part of the Pottsville conglomerate series. It may, however, represent the Mauch Chunk shales."

The section at Patton Station was probably better exposed at the time of the Second Survey and the following section is that given by H. M. Chance[5] in his report on Clarion County:

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[4] Platt, op. cit., p. 84.

[5] Chance, H. M., The geology of Clarion County: Second Geol. Survey of Penna., vol. VV, p. 116, 1880.

Section at Patton Station

		Feet
1.	Homewood sandstone, hard and massive	40
2.	Shale, with streaks of coal	20
3.	Ore bed	1
4.	Shale	15
5.	Sandstone	25
6.	Shale, with kidney ore	35
7.	Sandstone and shale	50
8.	Shale, some sandy layers, ore balls	40
9.	Sandstone, with some interbedded shale	40
10.	Red shale	5
11.	Shale and sandstone to stream level	25

Chance referred the red shale (10) to Mauch Chunk. On the basis of this outcrop of red shale and the assumption that it was Mauch Chunk the Second Survey mapped the Mauch Chunk throughout much of northwestern Pennsylvania where it is now known to be absent.

David White of the U. S. Geological Survey visited this locality about 1900 and saw the red shale exposed near Patton Station. In personal correspondence to this Survey he reports as follows on what he then observed.

> I find that my barometer recorded about 200 feet of probably Pottsville on the west side of Redbank Creek coming in from Shannodale down to Patton Station. (In pencil notes he says some of it may be Mississippian.) According to my notes there was a small bed of red shale in the railroad cut near the road crossing, and a short distance north of the road crossing near the station I obtained fossil plants of lower Mississippian age. I should say that they probably indicate a horizon in the Burgoon sandstone or near the top of that sandstone.

Since the Pottsville-Pocono contact cannot be definitely distinguished anywhere in the quadrangle, the base of the Pottsville has been mapped at 200 feet below the top of the Homewood sandstone or about 280 feet below the Vanport limestone.

The Pottsville strata are exposed along all the main streams of the quadrangle and many of the tributary streams. They form rather steep valley sides that are densely wooded and strewn with large sandstone boulders, thus being unsuitable for farming (pl. 12, A). Generally the brow of the valley walls is the Homewood sandstone. The Pottsville crops out along the entire length of Redbank Creek in this quadrangle; also along its main head tributaries, the North Fork, Sandy Lick, and Mill Creeks, and several miles up the smaller tributaries. It is barely above drainage at Summerville in the trough of the Fairmount syncline. Ascending Little Sandy Creek, it descends rapidly from the brow of the valley and passes below drainage a short distance east of Langville. It rises again on the west flank of the Sprankle Mills anticline at Cool Spring and occupies the lower part of the valleys in the vicinity of East Branch. In the northern part of the quadrangle, the Pottsville crops out over broad areas in the valleys of Mill Creek, North Fork, Little Mill Creek, Pekin Run, Craft Run, Red Lick Run, and smaller tributaries. Just north of the quadrangle it spreads out over the divides and occupies the uplands.

PLATE 12

A. Typical Pottsville topography, Eldred Township.

B. Homewood sandstone flat near Richardsville.

There is a small area of outcrop at the southern boundary of the quadrangle in the vicinity of Sprankle Mills.

Homewood sandstone. The topmost member of the Pottsville is a generally gray, coarse-grained, cross-bedded, massive sandstone, averaging about 40 feet in thickness. However, it is sometimes represented by shaly sandstone or even by shale. The Homewood is exposed in Tunnel Hill, Brookville along the road to the school house over the tunnel. The Homewood crops out at the school house in Richardsville in the northeast part of the quadrangle and forms the brow of the valley of North Fork at this point (pl. 12, B). Frequently the outcrop of the Homewood is marked by huge and massive boulders forming rock cities, as on the west side of North Fork along the road descending to Moore Bridge and also near the head of Swamp Run. The Homewood is exposed in cuts of the New Bethlehem road along Clement Run about one mile southwest of Brookville. In the southwest part of the quadrangle the Homewood is again exposed along the State road just east of Mayport and at Langville on Little Sandy Creek, where it is buff, massive and coarse-grained. At Sprankle Mills, boulders are conspicuous in the valley (pl. 13, A). Here it appears as a coarse, white, loosely cemented sandstone. The Homewood sandstone is a marked feature of the geology of the northwest part of the quadrangle where it occupies the brow of the valleys of Mill Creek and Little Mill Creek. The sandstone ledges at Hazel Dell School in Mill Creek Township mark the top of the Homewood. Likewise, in Beaver Township along Beaver Run, it is the Homewood sandstone that forms the crest of the valley walls and ascends the run to Conifer, where it lies in the valley bottom directly under the Brookville coal and just above drainage level.

Mercer shale and coal member. An extremely variable member consisting mostly of dark shale but including one or more thin coal seams and some clay, represents the Mercer. It varies in thickness from a few feet to possibly 70 feet, although the general average is about 30 feet. The horizon is usually obscured by the sandstone float of the overlying Homewood. The Mercer is exposed in Tunnel Hill, Brookville, along the road from the school house down to the creek at the sharp turn of the road where an old entry was once driven for clay, and also along the Lakes-to-Sea highway east of Brookville, at the Pittsburg & Shawmut Railroad bridge. The sections are as follows:

Mercer sections at Brookville

Tunnel Hill

	Ft.	in.
Sandstone, Homewood	20	
Coal	1	8
Clay	0	3
Coal	0	3
Clay	2	6
Concealed	17	0
Coal blossom	0	3
Flint clay	1	0
Concealed	11	0
Coal	0	8
Sandstone, Connoquenessing	84	0

East Brookville

	Ft.	in.
Sandstone, Homewood	10+	
Shale	3	
Clay	0	10
Shale	7	
Shaly coal	0	10
Coal	2	6
Clay	1	6
Shale	3	6
Coal	2	6
Sandy clay	0	2
Sandstone, Connoquenessing	60	

The Mercer coals, generally two in number, have been prospected and dug for house coal in several places in the northern part of the quadrangle. Along the Richardsville road, at the road intersection just south of Pekin Run, the Mercer shows 2 feet of coal in outcrop. It is overlain by 40 feet of massive, coarse-grained, buff Homewood sandstone. There are several abandoned country coal banks in this seam west of the road.

Along North Fork the Mercer coal is opened in small banks for country trade. Here it averages about two feet in thickness. A thinner seam occurs about 15 feet above it. To the west, along Mill Creek in Eldred Township, the Mercer horizon carries two thin coal seams which have been dug from time to time for house coal, but are apparently too thin for commercial development.

The Mercer shale is exposed along the highway about one mile northeast of Summerville in a road cut east of Welch Run. Here the Mercer coal is approximately one foot thick. About 2 miles up Welch Run, almost in its bed, the Mercer coal is mined in a small country bank beneath the viaduct of the New York Central Railroad. The coal is about 3¼ feet thick and is 135 feet below the Vanport limestone which is exposed in the railroad cut above.

Section along New Bethlehem highway 1 mile east of Summerville

	Ft.	in.
Sandstone, weathers into thin slabs (exposed)	20	
Shale	7	
Coal	1	
Fire clay	1	
Gray clay shale	3	
Carbonaceous streak of clay	0	3
Dark gray clay shale	15	
Sandstone, coarse-grained, top exposed	—	

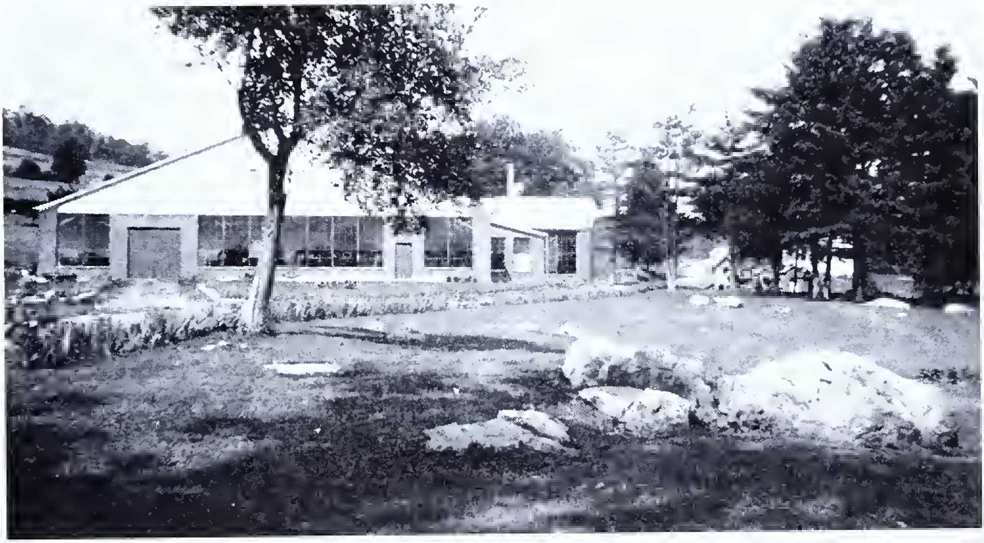
In the southwest corner of the quadrangle, on both sides of Redbank Creek, the Mercer clay and coal is developed. The clay is mined just outside the quadrangle on the south side of the creek opposite Mayport where the following section was obtained:

Section of Mercer and Connoquenessing members
Mayport Fire Clay Co., Redbank Township, Armstrong County

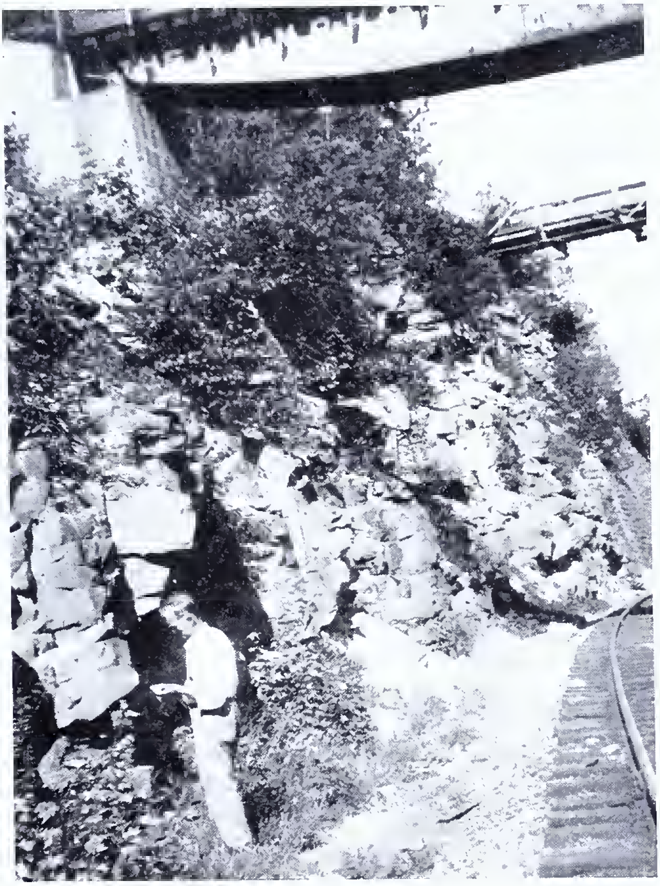
	Ft.	in.
Coal	1	6
Concealed	18	
Coal	0	8
Clay	9–16	
Coal	1	6
Clay	2	
Drab shale	6	
Sandstone, massive (two thin coal layers near top, irregular and non-persistent)	10	
Shaly sandstone	8	
Sandstone, massive, buff, cross-bedded	30	

At Port Barnett in the narrow spur around which Sandy Lick Creek makes a sharp bend, the Humphrey Brick and Tile Company has a quarry above the Garrison cut of the Pennsylvania Railroad.

PLATE 13



A. Boulders of Homewood sandstone at Sprankle Mills.



B. Connoquenessing sandstone in Garrison's cut on Pennsylvania R.R., Brookville.

The section in this quarry consists of a succession of clay, shale, and coal beds totaling 80 feet which lies between two massive sandstones. The age of these beds has been the subject of considerable speculation and they have been placed in the Brookville-Clarion horizon and also in the Mercer. Unfortunately the Vanport limestone is lacking in this region. The author believes, after tracing the massive Connequenessing sandstone for a considerable distance and studying detailed sections from around Brookville, that these beds must include both the Mercer and Brookville horizons. The following section is compiled from measurements in the quarry and from diamond drill records in the vicinity:

Section at New Humphrey quarry, 1 mile southeast of Brookville

	Thickness		Total	
	Ft.	in.	Ft.	in.
Sandstone, tan	12		12	0
Coal	1	7	13	7
Fire clay	9-14		23	7
Concealed	6		29	7
Shale	16	3	45	10
Shale, black fissile	1	1	46	11
Coal	1		47	11
Clay	5		52	11
Shale, black fissile	6	8	59	7
Sandstone, speckled white	0	3	59	10
Shale	3		62	10
Coal	1	4	64	2
Clay	5	2	69	4
Shale, with "ironstone" concretions	4		73	4
Coal	0	3	73	7
Clay, plastic	1	3	74	10
Clay, shaly	5	7	80	5
Coal (cannel character)	0	9	81	2
Shale, black fissile	1	0	82	2
Coal	1	11	84	1
Shale, carbonaceous	1	5	85	6
Clay	3	3	88	9
Clay, flinty	2	2	90	11
Coal	0	6	91	5
Shale, black	0	3	91	8
Concealed	3-5		96	8
Sandstone, white	106		202	8

The sandstone in the railroad cut seems most certainly Connoquenessing. The beds in the quarry are probably the Mercer and Brookville horizons with the Homewood sandstone lacking, and the sandstone at the top of the quarry is probably the Clarion sandstone. The 3-inch sandstone in the middle of the section was reported from one diamond drill hole and is a thin bed in the quarry. It may be a trace of the missing Homewood sandstone. The Mercer horizon is 40 feet thick. If the Brookville and Mercer horizons are considered as one large group, the thickness is 80 feet.

Connoquenessing sandstone. The lower part of the Pottsville series is occupied by a great thickness of fairly massive sandstone, generally white to gray and fine grained. The thickness of the Connoquenessing is at least 90 feet, as seen and measured in numerous exposures in the railroad cuts and the creek bluffs around Brookville (pl. 13, B). The Connoquenessing sandstone is present along the ravines of the principal streams but is rarely well exposed except in the railroad cuts. It is exposed along the Pennsylvania Railroad east of Mayport in the southwestern part of quadrangle and in the vicinity of Heathville. In the northern part of the quadrangle it crops out along Mill Creek and North Fork, but the exposures are poor.

The bottom of the Connoquenessing, or the base of the Pottsville, is practically indeterminable with any degree of accuracy in this area. The top of the Pocono consists of sandstone lithologically similar to the Connoquenessing.

There are no exposures revealing anything like a complete succession down through the Connoquenessing and the upper part of the Pocono.

MISSISSIPPIAN SYSTEM

Mauch Chunk series. The Mauch Chunk, which has a thickness of several thousand feet of red shales and interbedded thin sandstones in the eastern part of the State, is apparently not represented at all in the Brookville quadrangle. The Mauch Chunk, as originally deposited, appears to have decreased in thickness from east to west. After the deposition of the Mauch Chunk, central Pennsylvania was uplifted above sea level. During this emergence the Mauch Chunk was removed by erosion in this quadrangle, if indeed it was ever deposited. North of this region even some of the underlying series was eroded. The Mauch Chunk, as exposed on the Allegheny Front, consists of red and green shales and sandstones with some drab shales and gray sandstones. Rocks of Mauch Chunk age were not seen in this quadrangle although, if present, they should appear in the valley of Redbank Creek and along Mill Creek and North Fork.

Platt[1] in his Jefferson County report for the Second Pennsylvania Geological Survey mentions the occurrence of a few feet of red clay shale at Patton Station on Redbank Creek. He placed this shale as most probably in the Pottsville series, 220 feet below the top of the Homewood sandstone. As a matter of fact, the structure map of the Vanport limestone indicates that this red shale would be about 400 feet below the Vanport. Although Platt believed that the red shale was most probably a part of the Pottsville, he said that it might represent the Mauch Chunk and proceeded to show the Mauch Chunk on the Jefferson County geological map at this horizon.

H. M. Chance[2], in his report on Clarion County for the Second Geological Survey, notes this occurrence of red shale, observes that it is 325 to 400 feet below the Vanport limestone and calls it the Mauch Chunk. He likewise shows it on the geological map as a red band of Mauch Chunk.

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[1] Idem, vol. H6, p. 84.
[2] Idem, vol. VV, p. 58.

In his report on Armstrong County, Platt[3] refers to this red shale at Patton Station, says it is 290 feet below the Vanport limestone and places it definitely in the Pocono.

David White visited this locality some years ago and at that time observed an exposure of red shale. In a personal communication he makes the following statement: ''According to my notes there was a small bed of red shale in the railroad cut near the road crossing, and a short distance north of the road crossing near the station I obtained fossil plants of lower Mississippian age. I should say that they probably indicate a horizon in the Burgoon sandstone or near the top of that sandstone.'' On the basis of this evidence and lack of any other exposures that might be considered Mauch Chunk, it is concluded that the Mauch Chunk series is absent in the Brookville quadrangle.

Pocono series. The oldest rocks exposed in the quadrangle belong to the non-marine Burgoon sandstone of the Pocono series, named from Burgoon Creek in Cambria County, Pa. Only the upper part of the Pocono is above drainage and consists principally of sandstone with some interbedded shale. This sandstone is in part the Mountain or Big Injun sand of the driller's log, for in this region the Mountain or Big Injun as reported in many well logs undoubtedly also includes the Pottsville sandstones. The Burgoon is unevenly bedded, usually massive, often cross-bedded, fine-grained to medium-grained, not very clean, and tends to weather in slabs an inch or two in thickness. It includes lenses of gray to green, soft and clayey shale, the largest observed being 30 feet thick. In the Foxburg-Clarion area to the west of the Brookville quadrangle the total thickness of the Burgoon is given as 310 feet. In the Brookville quadrangle probably not more than 200 feet is above drainage and this is only partly exposed.

The Burgoon sandstone crops out in the gorge of Redbank Creek between Heathville and the mouth of Little Sandy Creek. The best exposures are in the cuts along the Pennsylvania Railroad; the exposure at Patton Station has already been described. In a railroad cut just south of Heathville 30 feet of massive sandstone is exposed. The sandstone is probably very close to the top of the Burgoon since the top of the Pottsville is placed in the adjoining hill at 1,400 feet. The top of the 30 feet of sandstone in the railroad cut is about 215 feet below the top of the Pottsville, which could put this sandstone near the top of the Burgoon. A very short distance to the south another cut reveals 30 feet of gray sericitic shale which evidently occupies approximately the same horizon.

The upper part of the Burgoon undoubtedly is above the drainage in the gorges of Mill Creek in Clarion County, and North Fork, Mill Creek, and Sandy Lick Creek in Jefferson County. There are practically no exposures in these ravines because of the talus cover on the steep, wooded slopes from higher sandstones. Therefore, the Burgoon has been mapped here by interval from what is thought to be the top of the Homewood sandstone. There is opportunity for considerable error in that the Clarion sandstone is apparently massive and, in a region of infrequent outcrops, may be easily confused with the Homewood sandstone.

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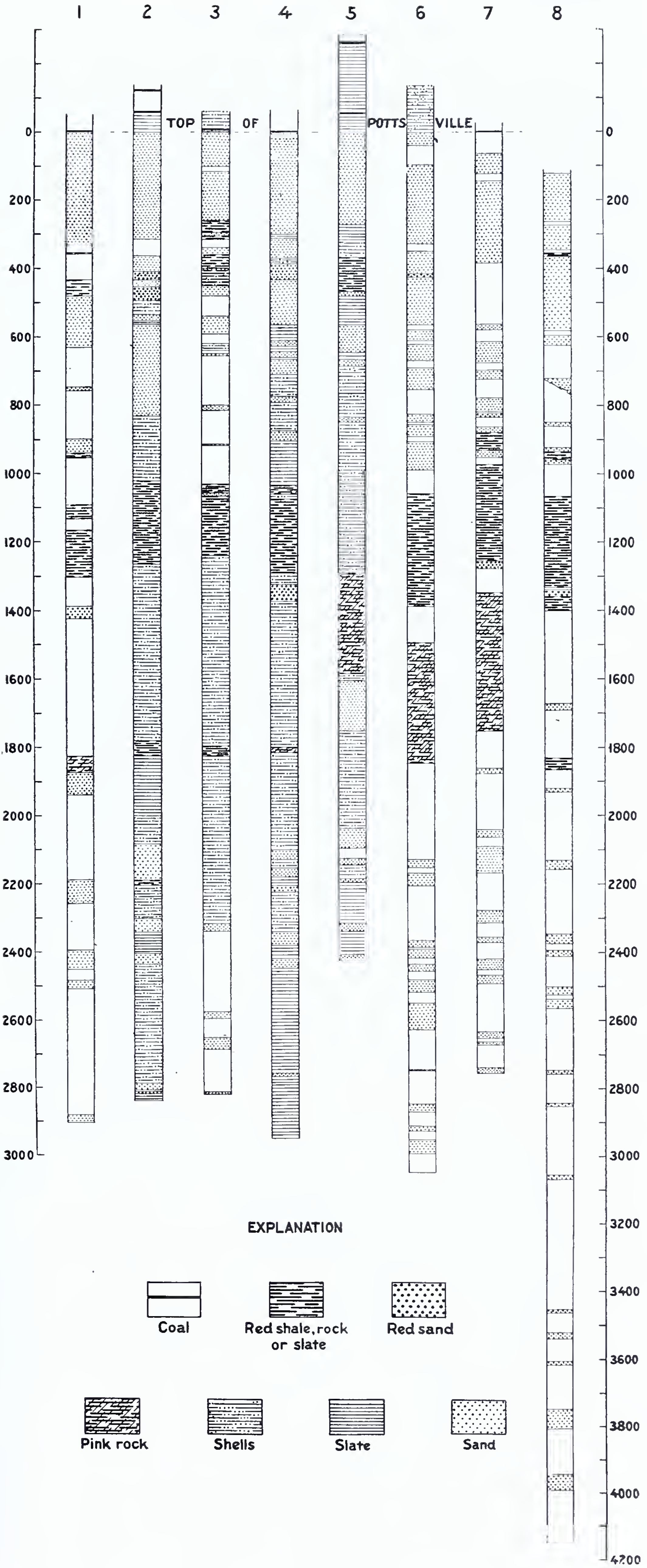
[3] Platt, W. G., Pennsylvania Second Geol. Survey, vol. H5, p. 188, 1880.



Drill records showing the character of the strata below the top of the Pottsville series.

ROCKS NOT EXPOSED

Something of the nature of the strata that lie below the surface in the Brookville quadrangle has been learned by a study of the records of deep wells. This information is augmented by investigations of the concealed rocks made by geologists in adjacent areas where they are exposed. Many of the wells have reached depths of 3,000 feet and a few have reached depths of 4,000 feet. The limits of the formations cannot be determined accurately since no direct paleontologic evidence is available to indicate the age of these beds, and the lithologic nature of the beds as described in the drillers' logs is too general. The unexposed strata penetrated by these wells represent the Pocono group of the Mississippian system and portions of the Catskill and Chemung formations of the Devonian system.

The gas well records in the Brookville quadrangle reveal only the general nature of the underlying strata. The following discussion is based on the records of ten gas wells in Rose and Pine Creek Townships, selected because the logs are fairly complete and the top of the Pottsville could be definitely ascertained by the known position of the Brookville coal. (See plate 14). The location of the eight wells on plate 14 follows:

1. U.N.G. 3055. Burns farm, Rose Township.
2. U.N.G. 3033. Bonner farm, Rose Township.
3. U.N.G. 3035. Johns farm, Rose Township.
4. U.N.G. 3074. J. T. Burns farm, Rose Township.
5. U.N.G. 2960. Galbraith farm, Rose Township.
6. U.N.G. 3627. R. B. Reitz farm, Rose Township.
7. U.N.G. 3018. Heasley farm, Rose Township.
8. Humphrey Brick and Tile Company, No. 30, Fuller farm, Pine Creek Township.

It is more convenient to discuss the stratigraphic position of these unexposed rocks with respect to the top of the Pottsville because the Big Injun sand as reported in the well records obviously includes both the Pottsville and the upper Pocono sandstones and it is impossible to distinguish that contact. The average thickness of the Big Injun sand as recorded in these wells is 300 feet, the maximum being 370 feet and the minimum 220 feet. As has been shown by previous discussion, it is thought that the upper 200 feet probably represents the Pottsville, so that the remainder would constitute the sandstone of the upper Pocono, the Burgoon sandstone. At approximately 400 feet below the top of the Pottsville, many of the records show "red rock," ranging from 30 to 100 feet in thickness, sometimes directly under the Big Injun sand and sometimes separated by a varying interval of shale. This red rock is believed to be the Patton red shale and, in several of the wells, red sand is noted at approximately this horizon.

Below this "red rock," down to about 1,000 feet below the top of the Pottsville, there is a succession of sands varying greatly in number and thickness. In some wells this interval consists largely of a succession of sands separated by thin shales, and in others the interval is predominantly shale with a few fairly thick sands. These sands have been variously designated by the drillers as Gas, Hundred-foot, Murrysville, and others, but it seems presumptive to assign these names definitely to these sands when they have not been traced to the type localities, and especially does it seem unwarranted when one attempts to trace these sands from well to well over the limited area of a township. This group of sands lies in an interval from 600 to 900 feet below the top of the Pottsville. It probably represents the Oil Lake series as defined by K. E. Caster.[1]

Below these sands comes an interval about 100 to 140 feet thick which consists mainly of shale and is underlain by the "Big Red Rock" of the driller. These shales may possibly represent Caster's Kushequa shale of Mississippian age and the Oswayo shale of Devonian age. The data are too meager to identify definitely the base of the Mississippian in this region, so that one is justified in saying only that it probably occurs in the lower part of this interval, probably not more than 140 feet above the "Big Red Rock."

The "Big Red Rock" is the principal horizon marker used by the driller in this region. It occurs approximately 1,000 feet below the top of the Pottsville and represents the Catskill phase of deposition. Whether it is post-Chemung or Chemung in age must remain for more detailed future stratigraphic study to determine. This red rock is predominantly shale but includes sandy horizons. It averages about 300 feet in thickness and is underlain by a fairly persistent sandstone about 20 to 40 feet thick and approximately 1,300 feet below the top of the Pottsville which the driller usually calls the Deemer sand or the Fifth sand.

The horizon called the "Pink Rock" by the drillers is about 1,340 feet below the top of the Pottsville. This consists mainly of shale with some thin sandstones. It is thought to be upper Chemung in age. The base of the "Pink Rock" is at about 1,800 feet below the top of the Pottsville.

Below the "Pink Rock" the section is largely composed of shale down to a group of sands, the top of which is called the Speechley sand. This sand seems to be fairly persistent and occurs approximately 2,100 feet below the top of the Pottsville. The section from here down to the so-called Kane sands of the driller, about 2,800 to 2,900 feet below the top of the Pottsville, consists of interbedded thin sandstone, shaly sandstone, and shale. These are the productive gas sands of the region and are thought to be Chemung in age.

In Pine Creek Township a few wells have penetrated to 3,000 feet below the top of the "Big Red Rock." These wells reveal a number of sands ranging from 10 to 100 feet in thickness, and interbedded with shale. It is thought that these wells also are in Chemung strata because, in general, in southwest Pennsylvania where the underlying Portage is definitely recognized, it is predominantly shale with very few sands. For this reason, it is doubtful if any of the wells in the Brookville quadrangle have reached the Portage.

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[1] Caster, K. E., The stratigraphy and paleontology of northwestern Pa.: Bull. Amer. Paleontology, vol. 21, no. 71, pp. 46, 63, Ithaca, N. Y., 1934.

STRUCTURE

Definition

Structural geology is the phase of geology that concerns the attitude or position of the rocks, and particularly any deformational change in attitude which they may have experienced since the time of their formation. The rocks in western Pennsylvania are sedimentary in origin and were deposited originally as unconsolidated sediments in approximately horizontal beds. They are no longer in that position, having been subjected to great pressure, apparently directed from the southeast, which raised and squeezed the beds into undulating folds trending from northeast to southwest. East of the Brookville quadrangle the folding is more intense and even broken by faulting while to the west and north the marked northeast-southwest folds gradually die out and the structure becomes warped and gentle.

The angle formed by the inclination of the bedding plane to the horizontal is called the dip of the bed. The direction of the line of intersection between the bedding plane and the horizontal is called the strike. In general, the beds in this region dip to the northwest or to the southeast, and hence the strike is generally in a northeast-southwest direction. A fold in which the rocks are arched upward and the beds dip away from an axis is called an anticline. When the beds dip downward toward an axis to form a trough, the structure is called a syncline. The line tracing the highest part of an anticline or the lowest part of a syncline is called the axis. These axes are not horizontal but rise much higher or fall much lower in some areas than in others, thus creating a plunging character for the whole structure. In general, in this region the axes of the synclines and anticlines tend to plunge to the southwest or, conversely, rise toward the northeast. Along the axes of the anticlines are high areas called domes and depressed areas called saddles. Where the rocks dip in one direction only, as in a limited area on the flank of a syncline or anticline, the structure is called a monocline.

Importance of geologic structure

Knowledge of the geologic structure of a region is of considerable value in mining operations and in prospecting for oil and gas. Frequently farmers desire to find on their land a certain coal or limestone bed that is being worked on neighboring land. A farmer usually levels from that place to his land, perhaps across a valley or over a hill and expects to find the coal or limestone at the same level or elevation. Very likely, however, in this region the beds dip or rise, as the case may be, from the neighbor's "digging" and he fails to find the desired bed. It is, thus, important to know the structural trend of the beds in that particular locality. In this connection, it is important to emphasize that the structure of the rocks, that is, the rise and fall of the beds, bears no relation to the surface. A syncline does not always lie beneath a valley nor an anticline under a hill. The very opposite condition may hold.

In prospecting for gas it is frequently desirable to know how deep one must drill to reach the particular horizon that is gas-bearing. Again, one must consider not only the difference in surface elevation between the two points, but also the difference in elevation of the gas-bearing horizon; in other words, the structural factor. In prospecting for oil and gas, it is well known that there is a tendency for these substances to accumulate in the anticlines and hence the anticlinal areas are often the most favorable places to prospect.

For the geologist, it is obviously extremely important to keep the structural trend in mind in correlating the various strata from place to place.

Method of representing structure

Structure may be represented in three ways:

1. By cross sections.
2. By symbols indicating the direction of the strike and the direction and amount of dip at a particular locality.
3. By structure-contour lines.

The first two methods are better adapted for regions in which the rocks are sharply folded and faulted. The third method, the use of structure-contour lines, is used in a region where the folds are very gentle and the dips are too low to be measured accurately and where there is little or no faulting. In such a region the structural features would be scarcely perceptible in a cross section so that contour lines reveal the structure much more clearly. This is the method adopted in this report.

In the structure-contour method a suitable key horizon or reference stratum is selected. In this quadrangle, the Vanport limestone was used because it is easily recognized and occurs in a very large part of the quadrangle and is the reference stratum used in adjacent areas to the west and southwest. Wherever possible, elevations above sea level were obtained on the Vanport limestone by aneroid barometer readings or careful hand leveling from a known elevation. In many places the elevation of the Vanport limestone was obtained in outcrops, mines, pits, or wells. Many drill holes recorded the presence of the Vanport limestone, and its elevation in such cases was computed where the elevation of the top of the drill hole was known. In some parts of the quadrangle where the Vanport does not occur or is not exposed at the surface, the approximate elevation was obtained by computing the interval from some other recognizable stratum, usually the Upper Freeport, Lower Kittanning, or Brookville coals. The average interval between the beds was obtained at all places where two or more recognizable beds were found in outcrop or borings. Thus, where a bed above the Vanport limestone was found, its elevation was obtained and the average distance or the nearest measured distance to the Vanport limestone was subtracted. For beds below the Vanport limestone, the average interval was added, thus giving the approximate elevation at which the Vanport limestone would occur if it were present.

Points of equal elevation of the Vanport limestone as thus obtained were connected by lines which are called contour lines. These lines were drawn for every 25-foot change in elevation so that the contour interval is said to be 25 feet. The intersection of a surface contour line with a structure contour line of the same elevation denotes a point of outcrop of the Vanport limestone.

Each of these structure contour lines coincides with a line which might be traced along the top of the Vanport limestone at the indicated elevation above sea level. For example, a contour line marked 1,500 feet indicates that the top of the Vanport limestone lies 1,500 feet above sea level everywhere along that line. Along any one contour line the Vanport limestone is 25 feet higher or lower than along the next adjacent line. Therefore, the spacing of the contour lines indicates the relative steepness of the dip of the beds. Where the dip is steep, the lines are close together; where the dip is gentle, the lines are much farther apart.

The relation between the structure contours and the topographic contours is important for, by that relation, the position of the Vanport limestone can be determined in any part of the quadrangle. For example, if it is desired to know the depth to the Vanport limestone at Stanton, it can be answered by referring to the structure contour map. Stanton lies between the 1,475- and 1,500-foot structure contour lines. The elevation of the bed is therefore about 1,490 feet. The road intersection at Stanton is 1,600 feet, hence the bed lies at a depth of 110 feet. If we know that the Lower Kittanning coal lies at an average interval of 50 feet above the Vanport limestone in the region, we can further determine that the depth to the Lower Kittanning coal is 60 feet at Stanton by subtracting 50 feet from 110 feet. Or, if we know that the Brookville coal lies at an average interval of 80 feet below the Vanport limestone, we can determine that the depth to the Brookville coal is 190 feet at Stanton by adding 80 feet to 110 feet.

Accuracy of structure contours

The accuracy of the structure contours depends upon three factors: the precision of the elevations obtained directly; the variability of the intervals between the key rocks; and the number and distribution of the points whose elevations are known. Most of the elevations of the coal and limestone outcrops and the mines and country banks were obtained with a hand level, and the possible error is probably less than three feet. Where the outcrops or country banks were some distance from a bench mark and involved difficult leveling through woods, the elevation was obtained with an aneroid barometer carefully checked with the topographic map, and the possible error is probably 10 feet. The possible error for the second factor is probably 10 feet. The effect of the third factor varies in different areas. In nearly all the quadrangle, except the area north of the Lakes-to-Sea Highway and the area east of Indiancamp Run, points at which the elevations of recognizable horizons have been determined are numerous and evenly distributed. Along the northern and eastern borders of the quadrangle it was difficult to identify accurately the few outcrops that occur but many gas wells have been drilled in these areas. Here the structure is based largely on elevations obtained on the top of the "red rock"* which is recorded in most of the wells. As the interval to the Vanport limestone in the nearest adjacent area was used, this introduced a larger possible error than in other parts of the quadrangle. For this reason, the structure contours merely show the trend of the structure in those areas and have been indicated by dashed lines. When all the possibilities of error are allowed for, it may be assumed that the structure contours are correct within a contour interval except possibly along the northern and eastern borders where the data are so meager that the error may be greater.

General description

Former ideas of structure. In the report of the Second Pennsylvania Geological Survey on Jefferson County[1] Platt describes five anticlines and four synclines that cross the Brookville quadrangle and represents the axes of the anticlines on the geological map by straight and parallel lines drawn approximately N.35°E. Their names and position, beginning at the southeast, are given below:

Perryville anticline, at the southeast corner of the quadrangle.
Smicksburg syncline, passing approximately through Markton and Burkett Hollow School.
Waynesburg or Roaring Spring anticline, along a line from Sprankle Mills to Iowa.
Leechburg syncline, passing through Worthville, Port Barnett, and Richardsville.
Brookville anticline, passing through Patton Station and Alaska.
Fairmount syncline, passing through Summerville, Roseville, and Howe.
Anthony's Bend anticline, passing through Sutton and Caldwell School.
Centerville syncline, passing about one mile northwest of Corsica and near the mouth of Kahle Run.
Kellersburg anticline, passing near the extreme northwest corner of the quadrangle.

Present survey. Instead of straight and narrow parallel folds, the present survey found broad, irregular and sinuous folds, trending more to the east, generally about N.50°E. Comparison of the axes of the structures as given by the Second Survey above with those obtained by detailed mapping and shown on the structure map accompanying this report reveal very great errors in the lines as formerly drawn. For instance, the low points at Worthville, Port Barnett, and Richardsville are connected in the Second Survey map and called the Leechburg syncline, whereas they are actually in three different synclines separated by two anticlines. Equally great changes in the position of other structures could be observed by a casual comparison of the two maps.

The Brookville quadrangle lies on the northwest edge of the region of definite northeast-southwest folds. Northwest of the Fairmount syncline the folding appears less intense and the northeast trend is not so well marked. The structure apparently becomes a warped surface that grades gradually into the monoclinal area of Venango and Forest Counties. The structures of the Brookville quadrangle undoubtedly continue to the northeast and probably join with the structures that have been traced across McKean and Elk Counties. The intervening area is still unmapped in detail so that it is impossible to state definitely how the structures tie in.

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* The "red rock" is the Catskill formation of Upper Devonian age.

[1] Platt, W. G., Report of progress in Jefferson County: Penna. Second Geol. Survey, Report H6, pp. xix—xxviii, 1881.

Detailed Structure

Sprankle Mills anticline. The Sprankle Mills anticline, named from Sprankle Mills in Oliver Township, crosses the southeast corner of the quadrangle. It enters from the Smicksburg quadrangle just east of Sprankle Mills, crosses Little Sandy Creek about midway between Cool Spring and East Branch, turns eastward and leaves the quadrangle about three-fourths of a mile southeast of Center Hill School. This structure may extend southwestward across the Smicksburg quadrangle and tie in with the Greendale anticline of the Rural Valley quadrangle. The structure is well marked and rather narrow between Sprankle Mills and Indiancamp Run. It is controlled by numerous elevations on the Vanport limestone and Lower Kittanning coal. The western flank is quite steep, as the Vanport rises 320 feet in the two miles from the trough of the Worthville syncline near Smith School to the crest of the anticline near Laurel Ridge School. The slope of the eastern flank is very gentle, about 50 feet to the mile, based on observations on the Vanport limestone. The contours in the extreme southeast corner are based on elevations obtained on the Lower Freeport coal, using an interval of 200 feet to the Vanport limestone which is the average interval in the Ramsaytown area.

East of Indiancamp Run the data are very meager and based on an assumed interval of 1,170 feet from the top of the ''red rock'' to the Vanport limestone. A few scattered wells indicate the presence of a ''high'' on the axis in this area. The structure appears to split in this area, with a nose extending southward to the southeast corner of the quadrangle. The beds continue to dip southeastward from the southeast corner approximately 180 feet to the mile for a distance of 4 miles to the axis of the Punxsutawney syncline.

Worthville syncline. The Worthville syncline is named for the village of Worthville on Little Sandy Creek through which it passes. In the southern part of the quadrangle northward to Worthville this structure coincides very closely with what Platt called the Leechburg syncline. From Worthville the course of the syncline is different from that described by Platt. It closely follows the valley of Little Sandy Creek for three miles, passes just east of Ramsaytown and west of Knoxdale, and crosses Sandy Lick Creek just east of the border about one mile northwest of Fuller. The extensive area of Conemaugh rocks in the vicinity of Ramsaytown and Knoxdale is thus due to this downfold and not, as stated by Platt, to a marked dimple at the center of the Waynesburg anticline (the Sprankle Mills anticline of this report).

The Worthville syncline, the deepest fold of the quadrangle, is fairly symmetrical and its axis rises continuously from southwest to northeast at the rate of 25 feet to the mile. The southeast flank of the syncline is well controlled by numerous elevations on the Vanport limestone and Lower Kittanning coal along Big Run from Worthville to Sprankle Mills. There is a rise to the southeast of 125 feet to the mile. Along Little Sandy Creek the dip is much steeper, about 180 feet to the mile. As the axis rises to the northeast the syncline becomes shallower with broad gentle flanks where it leaves the quadrangle. The western flank is fairly steep and rises rapidly at the rate of 130 feet to the mile to the crest of the North Freedom anticline. This flank is well controlled by elevations on the Vanport from Worthville to a little west of Langville and by elevations on the Brookville coal from Pansy to Conifer. In the Ramsaytown-Knoxdale area the control is based on the Upper Freeport coal. The economic importance of the Worthville syncline is that it is responsible for the principal areas of Freeport coal in the quadrangle.

North Freedom anticline. The North Freedom anticline is the most pronounced upfold of the quadrangle. The southwestern part of it is the fold that Platt called the Brookville anticline, connecting it with the anticline west of Brookville. Detailed work has shown that this is incorrect and the name Brookville has been dropped. The North Freedom anticline begins in the northeastern corner of the Rural Valley quadrangle, where it was called the Brookville anticline following Platt's nomenclature. It crosses the northwest corner of the Smicksburg quadrangle and enters the Brookville quadrangle at Mudlick Creek, whence it follows a nearly northward trend for a mile. It then turns northeastward, passes about a mile west of North Freedom, from which village it is named. It crosses Little Sandy Creek just east of the Armstrong-Jefferson County line and continues to a point just west of Ohl. A pronounced saddle or depression interrupts the northeast trend of the axis in the vicinity of Conifer. The structure is really a series of domes along a northeastward-trending axis. Northeast of the Conifer depression is another dome whose axis begins just southeast of Stanton, and passes west of McAninch School. Another saddle occurs between Swamp Run and Sandy Lick Creek. The axis crosses Sandy Lick Creek approximately one mile northwest of Iowa and leaves the quadrangle about a mile southeast of South Sulger.

The southwestern dome is the sharpest part of the structure. Its southwest closure is controlled by numerous elevations on the Vanport limestone and Lower Kittanning coal along Mudlick Creek. The eastern flank is quite steep, for the Vanport limestone descends into the Worthville syncline about 180 feet to the mile. The western flank is more gentle and dips about 120 feet to the mile. This flank is also controlled by elevations on the Vanport limestone. The northeastern closure was determined by scattered elevations on the Vanport limestone, the Clarion coal, and the Brookville coal. The exact position of the center of the dome is unfortunately poorly controlled but several elevations on a coal thought to be the Brookville seem to place the axis about three-fourths of a mile southeast of Patton Station. The axis apparently does not cross Redbank Creek as

Platt thought. This structure raises the Pottsville to the rim of the valley and brings the Pocono sandstone above drainage along Redbank Creek in the vicinity of Patton Station and also along the lower reaches of Little Sandy Creek which makes this region near the center of the dome wild and unsuitable for anything but forest growth.

The depression or saddle in the structure in the vicinity of Conifer is well controlled by elevations on the Vanport limestone and the Brookville coal, which is here just above drainage level and has been extensively mined.

Northeast of Stanton is a broader and flatter dome. The southeast flank dips about 160 feet to the mile; the northwest flank is more gentle, dipping 75 feet to the mile. The southwestern closure is controlled by numerous elevations on the Vanport limestone and the Brookville coal. In the region of the northeastern closure the Vanport member is missing from the section and other key horizons are not definitely recognizable. This closure is defined by numerous elevations on the "red rock" obtained from gas-well records and seems fairly certain. The southeast flank is controlled mainly by elevations on the Upper Freeport coal, while the northwest flank is controlled by elevations on the Vanport limestone, the Lower Kittanning and the Brookville coals.

The data northeast of Sandy Lick Creek are very meager. No coal bed could be satisfactorily identified and traced. The top of the Pottsville was used but it is easily confused with other sandstones and is an uncertain horizon at best. Elevations on the "red rock" obtained from gas wells were the chief basis for mapping the structure here and because of the less satisfactory character of the data, the contours are shown as dashed lines.

The broad flat structure north of Conifer was determined by numerous elevations on the Vanport limestone which has been dug in many places by the farmers.

The structure has been productive of gas throughout, although the southwest dome has not been as extensively drilled as one would suppose, probably on account of the inaccessibility of the region. The depression at Conifer preserves a large area of Brookville coal. The structure at the northeast raises the Pottsville to the uplands. This restricts farming activities to the divides, for the valleys are stony and suitable only for forest growth.

Fairmount syncline. The Fairmount syncline, named for Fairmount City on Redbank Creek in Clarion County, is the major structural feature of the quadrangle. It has been traced continuously to the southwest across the Clarion and Rural Valley quadrangles, through Kittanning, and becomes the Duquesne syncline of the Freeport and Pittsburgh quadrangles, finally dying out in the northwest corner of the Brownsville quadrangle.

The synclinal axis enters from the Clarion quadrangle about three-fourths of a mile northwest of Shannondale and closely follows the course outlined by the Second Survey to Summerville. Instead of continuing toward Roseville, as mapped by the Second Survey, the axis bends a little to the east and follows the valley of Redbank Creek to Brookville, whence it extends in the same direction to the eastern edge of the quadrangle. The area between Summerville and the Clarion quadrangle is really a basin. From Summerville to Baxter the axis rises rather rapidly at the rate of 60 feet to the mile. Thus, the numerous rock exposures along Redbank Creek show a perceptible dip to the southeast which probably led the Second Survey to place the axis of its Brookville anticline between Baxter and Coder. The present more detailed survey reveals this to be an error. From Baxter to the edge of the quadrangle the structural rise is much less pronounced, about 17 feet per mile. As far northeastward as Brookville the structure is well defined by numerous elevations on the Vanport limestone, the Lower Kittanning and Brookville coals. Beyond Brookville, the control is less satisfactory on the southeast flank but the northwest flank is fairly well determined by scattered elevations on the Vanport member. From Summerville the rise up the northwest flank is rather rapid to Sutton at the rate of about 110 feet per mile. From Brookville the rise to the northwest toward Roseville is more gradual, about 55 feet per mile.

In the vicinity of Summerville and to the southwest, this structure brings down the Upper Freeport coal so that small patches of it occur in the higher hills. Coincident with the rise of the synclinal axis, the Pottsville rises higher in the hills along Redbank Creek until at Brookville the top of the Pottsville forms the brow of the valley walls and the Pocono must be very near drainage level.

Roseville anticline. The Roseville anticline, named for the village of Roseville, lies west of the Fairmount syncline. It is an elongated dome which begins southwest of Roseville at Coder Run, crosses the Lakes-to-Sea Highway about three-fourths of a mile east of Roseville, passes about midway between Alaska and Howe and dies out near Moore Bridge. The southwest closure is quite definitely determined by elevations on the Vanport limestone and Lower Kittanning coal. The northern closure is less certain, as the Vanport has disappeared and the coal beds are uncertain. However, the data are supported by elevations on the "red rock" obtained from gas-well records. These elevations indicate an eastward branch of the structure, a low saddle separating the main dome from a high area at the eastern border of the quadrangle. The region immediately to the northeast has not been mapped in detail, but it is quite possible that this structure persists northeastward and ties in with the Hebron anticline of Elk and McKean Counties.

Corsica syncline. The name Corsica syncline has been applied to the broad shallow structural basin north of Corsica. It is defined in its southern part by elevations on the Lower Kittanning coal. Toward the north the data are very meager, the certain identification of key beds is difficult, and very few gas-well records are available. The structure appears to tie in with another syncline in the Richardsville area in the northeast corner of the quadrangle. These contours are based mainly on elevations on the "red rock" obtained from gas-well records. An interval of 1,050 feet was assumed to the Vanport.

This may introduce considerable error; therefore the contours are shown as dashed lines.

This syncline preserves a large area of Lower Kittanning coal in the vicinity of Corsica and, further, preserves a large area of Allegheny rocks in the northern part of the quadrangle, permitting agricultural development in this region which otherwise would be a wilderness like the area to the north of it.

Kellersburg anticline. The Kellersburg anticline is named for Kellersburg in the Rural Valley quadrangle. It is a strong structural feature across the Clarion, Rural Valley, Kittanning, and New Kensington quadrangles. Its influence is seen in the northwestern part of the Brookville quadrangle where its axis crosses the Lakes-to-Sea Highway just at the border. A few elevations on the Vanport limestone high in the hills denote its presence. It can be traced fairly accurately to Little Mill Creek. North of that the rock exposures are few and key beds are difficult to recognize. The anticline, as mapped in Mill Creek Township, is based on a few elevations on the "red rock" from gas-well records and is shown by broken contour lines on account of the meager data available. It is possible that this structure persists to the northeast and ties in with the Smethport anticline of Elk County. The wilderness around Mill Creek is undoubtedly due to the uplift of the Pottsville and Pocono rocks to a position high above drainage level.

Subsurface Structure

Structure contours drawn on the top of the "big red rock" of the driller's log (probably Catskill) in those parts of the quadrangle where well records are available, are fairly accordant with the contours based on the Vanport limestone. The two sets of contours show that the folds in the surface and near-surface rocks are developed also in the deeper Mississippian and Upper Devonian rocks despite the great intervening Pennsylvanian-Mississippian unconformity which has removed the Mauch Chunk and part of the Pocono from the section. Although the general character of the folds and the direction of the structural axes is much the same on the "red rock," in some instances the folds appear sharper. This is, however, misleading and is due to the variation in the interval between the Vanport limestone and the top of the "red rock."

In those parts of the quadrangle where the elevation of the Vanport limestone is known, the interval to the top of the "red rock" was computed wherever available in well records. A generalized convergence map was constructed showing a rather definite trend in the thickness of this interval (fig. 20). The greatest interval was 1,215 feet at Sprankle Mills, and this decreased to 1,080 feet at Alaska, a thinning of 135 feet in 13 miles. By coincidence, the greatest thickness of the interval occurs near the Worthville syncline so that this syncline appears much deeper and sharper on the "red rock" than on the Vanport limestone. This same variation in interval causes the North Freedom anticline near Patton Station to appear broader and flatter.

From the information available the detailed structure of the gas sands for any considerable area in the Brookville quadrangle cannot be determined.

Faulting

A fault is a break in the continuity of a bed of rock attended by a movement on one side or the other of the break so that what were once parts of one continuous bed are now separated. Faults, although not uncommon in parts of the plateau province near the Allegheny Front, are rare in the interior of the province. A few faults showing a displacement of only a few inches were observed in several exposures in this quadrangle, but are of such small extent as to be negligible. Coal miners frequently speak of a "fault" in a coal bed, meaning that the sandstone overlying the coal has thickened downward into the bed, thereby materially reducing its thickness or completely cutting it out. These so-called "faults" are features of deposition and are not to be confused with true faults, which may cut out a bed of coal by movement of the bed along a break.

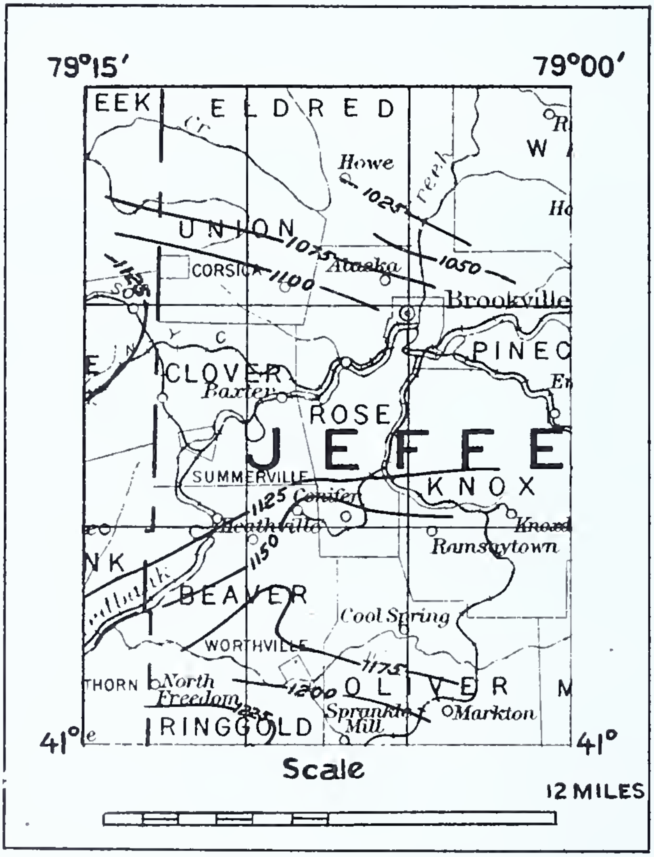


Figure 20. Convergence map showing areal variation in interval between the Vanport limestone and the top of the red rock (Catskill formation).

Unconformities

Two general types of unconformities occur in the sedimentary rocks of western Pennsylvania. In one type, the dip of the adjacent beds is different; from this it is assumed that the older beds were tilted and an irregular surface was formed by erosion before the later deposition of sediments which now make the overlying beds. Cross-bedding is common in practically all the sandstones and some of the shales in the quadrangle. The appearance of some of the exposures showing cross-bedding is similar to the unconformities just described, but careful examination will generally reveal the true bedding planes and their relation to the cross-beds.

The other type of unconformity is quite common. It reveals an irregular boundary between two adjacent beds and may or may not represent a hiatus. Such an unconformity is probably the result of subaerial erosion immediately following deposition of the lower beds. Therefore, the overlying sediments were laid down upon an irregularly eroded surface. This type of unconformity is evident between the Upper Freeport coal and the overlying Mahoning sandstone in the Ramsaytown-Knoxdale region. In many places the coal is thinned by a thickened sandstone which "comes down" from the roof and, in places, cuts out the coal entirely. Similar irregularities occur at other horizons, especially at the Brookville horizon which is frequently cut out by the overlying Clarion sandstone.

Rapid change in the character of the material being deposited may result in stratigraphic irregularity which resembles unconformable structure. This is especially true in the numerous occurrences of rapid transition from sandstone to shale or, as in the area north of Ross School, from limestone to sandstone at the Vanport horizon.

MINERAL RESOURCES

The principal mineral resources of the Brookville quadrangle are coal and natural gas. A large quantity of clay and shale occurs here although only two plants are at present engaged in the manufacture of clay products. Limestone is present in several horizons, but the beds are thin and no commercial developments are likely. Certain areas in the quadrangle show an abundance of sandstone more suitable for rough masonry than for fine building stone. Iron ore was dug at one time within the quadrangle but its nature is such that it has no value as an ore at present.

The mineral resources map

Plate III is the map which shows the mineral resources of the Brookville quadrangle and their relation to each other. For easy reference the map has been divided into a grid pattern of 36 rectangular areas. There are six vertical and six horizontal rows of these "blocks." Thus, one may quickly locate the small village of North Freedom by knowing it lies in the area Af, which is the area at the intersection of the vertical row A and the horizontal row f. In like manner, De4 refers to location 4 in the area De.

The patterns used on the map refer to specific rock groups or series. Thus, pattern Cbg covers the area in which the Burgoon sandstone of Mississippian age crops out at the surface or immediately underlies the mantle and talus. Pattern Cpv covers the area that is directly underlain by the Pottsville group and the rocks which are below it in the stratigraphic column. Pattern Ca1 covers the area that is underlain by the rocks between the base of the Brookville coal and clay horizon and the base of the Lower Kittanning coal. These rocks are at the base of the Allegheny group. Pattern Ca2 covers the area underlain by the rocks between the base of the Lower Kittanning coal and the top of the Upper Freeport coal. These rocks are the uppermost of the Allegheny group. Pattern Ccm covers the area directly underlain by the Conemaugh group, which comprises all the rocks above the Upper Freeport coal in this quadrangle. Pattern Qal covers the areas where alluvium has accumulated in flat stream valleys.

The position of all the important coal beds is shown by outcrop lines. Thus, the line that bounds the lower edge of pattern Ca2 marks the position along which the Lower Kittanning coal crops out or may be found. The upper boundary of pattern Ca2 is a line marking the location of the Upper Freeport coal. Between these two the Middle Kittanning coal is locally developed and its position is marked by a line within the pattern. Along the so-called crop lines the location of the important mines is indicated and these are referred to in the text according to their position, such as Dc2, Ef3. Many abandoned mines, most of the country banks, and the outcrops are also shown on the map but are not numbered unless referred to in the text. Where the horizon of the less important coal beds is unknown, there is no line on the map. Where the horizon of the more important coals, namely the Brookville, Lower Kittanning, and Upper Freeport beds, is inferred, dashed lines are used to indicate the position.

The structure contours, printed on the map in brown, represent the actual surface of the Vanport limestone, which is shown where it crops out by a green line. The structure contours represent also the structural configuration of all the rocks. By using the contours to determine whether the rocks dip lower or rise higher, and knowing the average intervals between the stratigraphic horizons as presented in the text, one can determine at any place in the quadrangle the depth to definite coal or clay horizons. For example, assume the Upper Freeport coal crops out at an elevation of 1,600 feet where the structural contour is 1,400 feet. Half a mile away, where the elevation is 1,700 feet and the structure contour is 1,350 feet, the Upper Freeport coal is buried. What is the depth? If the structure had remained horizontal at 1,400 feet, the depth would be 100 feet (the difference between 1,700 and 1,600 feet elevation). However, since the rocks have all "dropped" 50 feet lower to a position of 1,350 feet, the depth to the coal is 150 feet.

COAL

Workable coal of this quadrangle occurs at seven horizons, namely the Upper Freeport, Lower Freeport, Middle Kittanning, Lower Kittanning, Clarion, Brookville, and Mercer. Figure 21 is a columnar section showing the number of coal beds, their average thickness, the average interval between them, and their relation to certain key horizons.

The Brookville quadrangle is in the northern part of the northern Appalachian bituminous coal region. It lies just north of the main area of the Freeport coals, only a limited area of which remains in the region described here. A large part of the quadrangle is, however, underlain by the Middle Kittanning, Lower Kittanning, and Brookville coals, all of which have been commercially exploited.

History of mining

The first person to mine coal in the region for general use was a colored man named Charles Anderson. He lived in Brookville and opened his pioneer mine about 1832 on the Joseph Clements farm north of Brookville. The bed was said to be about 2 feet thick. He transported the coal by wagon to Brookville where he retailed it from door to door by the peck, half bushel, and bushel. The price was 12½ cents per bushel. The census of 1840 reports coal mined and used in two places; Rose Township, 500 bushels per year, and Brookville, 2,000 bushels per year. At the time of the examination of this area by the Second Geological Survey of Pennsylvania, in 1880, many small country banks on the outcrops of the Upper Freeport, Middle and Lower Kittanning, Clarion, Brookville, and Mercer coal beds were in operation.

During the first decade of the present century, coal mining on a commercial scale was begun on the Upper Freeport coal of the Ramsaytown district and the Brookville coal in the Conifer district. In 1909 Ramsay No. 1 mine on the Upper Freeport produced 259,303 tons and the Conifer No. 3 mine on the Brookville coal produced 167,645 tons. Following this, other mines were opened and from 1913 to 1920 the mines of the quadrangle produced over a million tons annually. Then production rapidly decreased. Mines were closed and abandoned so that in the late thirties less than 50,000 tons were produced in the quadrangle annually. The falling off in coal production was not due to exhaustion of the coal resources, but rather to the fact that the larger areas of thick Upper Freeport coal were mined out and the demand was not great enough to accept poorer quality coal, like the Brookville and Lower Kittanning coals.

Activity in 1941

The years 1939 to 1941 witnessed a change in coal developments in the quadrangle. Several companies set up stripping-operations on the Lower Kittanning and Upper Freeport coal in the region between Summerville and Corsica. During 1940 an estimated 640,000 tons of coal were removed from these strippings alone. Including production from the few mines which are still active, close to 700,000 tons of coal were mined in 1940. Doubtless the increased industrial activity due to the 1940-41 national defense program has stimulated coal production in the area.

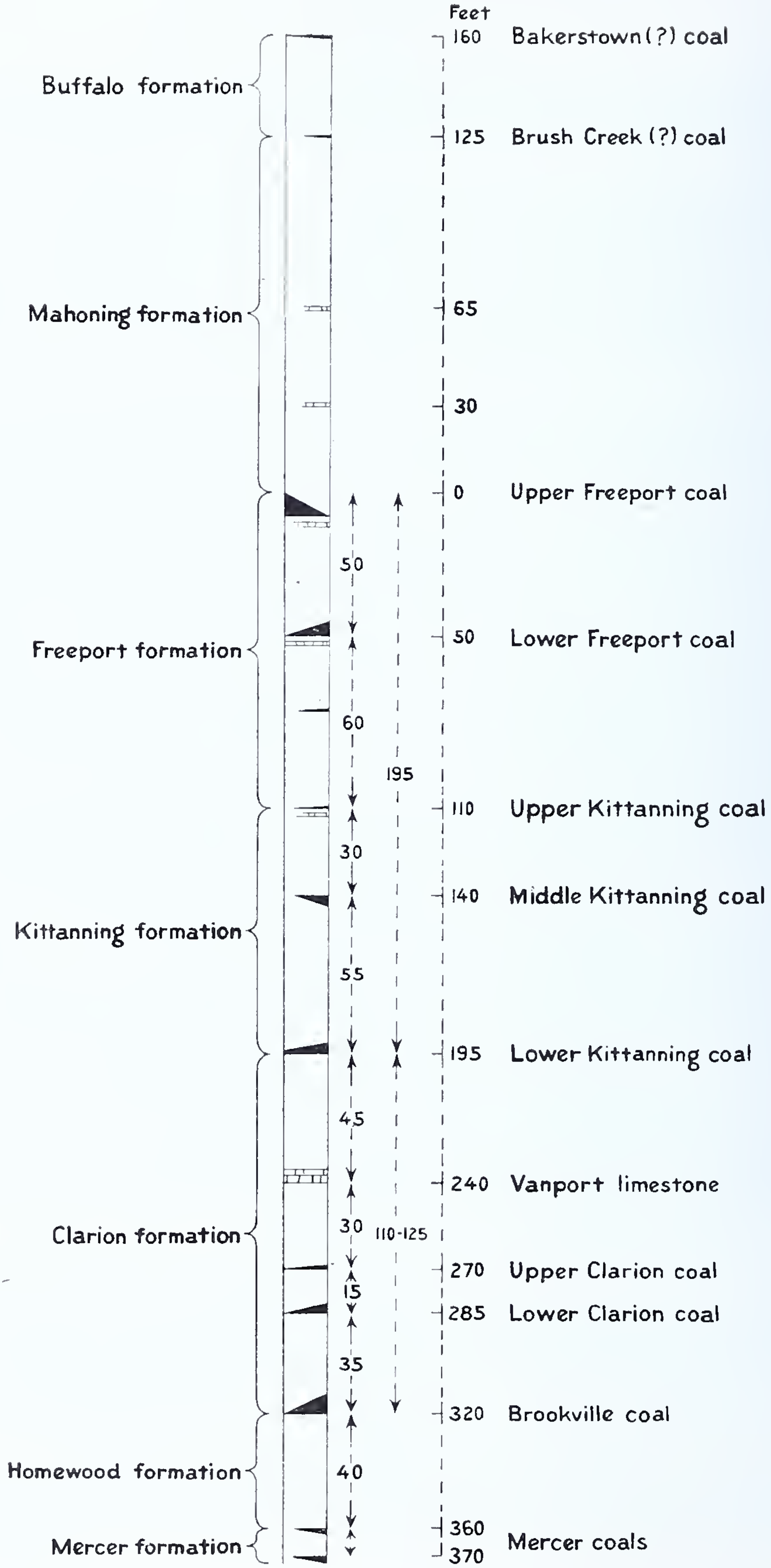


Figure 21. Generalized columnar section of coal beds showing the average intervals between them.

Stripping operations cannot expect a long period of activity. The thickness of the coal which most companies are stripping (Lower Kittanning) is rarely more than 36 inches and it averages about 30 inches. This means the limit of overburden may not be more than 30 feet for the coal to be removed at a profit. There are still many small areas where stripping operations can be carried on, but the intense activity of the present operations will rapidly exhaust these areas. Two companies, the Carrier Company stripping near Sutton, and the Elba Coal Company stripping near Holden, each removed an average of 1,000 tons a day during the summer months of 1940. Both companies have had to move the site of their operations several times.

Some of the mines in the area may expect increased production due to the current demand for fuel in expanding defense industries. Mines which are still operating include the Conifer No. 4 mine on the Brookville coal at Conifer, McGarey No. 2 mine on the Lower Kittanning coal east of Conifer, Helena mine of the Anita Coal Company on the Upper Freeport coal south of Stanton, and Sutton No. 10 mine on the Lower Kittanning coal at Sutton. The Sutton mine supplies all the coal for fueling the New York Central trains at Sutton, a total of about 30,000 tons each year. There are several country banks that operate sporadically to supply coal for local domestic use. These are not immediately important; a few could become fair sized producers if the demand became great enough.

Coal in the Conemaugh Group

The Conemaugh group is preserved only in the higher hills of a rather limited area extending from the vicinity of Knoxdale and Ramsaytown southwestward into Ringgold Township in the Worthville syncline and in small patches west of Summerville in the Fairmount syncline. Few exposures occur and the data are meager, but what information is available indicates that the coals are thin and of no economic importance.

About one foot of coal crops out in a lane in a high hill near the southern boundary of Knox Township between Lick Run and Indiancamp Run. This coal was once prospected by a drift (Ee8), now fallen in, but was not of workable thickness. It occurs at an elevation of about 1,725 feet and is approximately 125 feet above the Upper Freeport coal and may be the Brush Creek coal.

About half a mile south of Ramsaytown on the Levi Swabb farm, core drilling revealed about one foot of coal in several drill holes (Ee 9, 10 and 11) at an interval ranging from 146 to 157 feet above the top of the Upper Freeport coal. The coal is underlain by 2 to 4 feet of fire clay and overlain by 15 to 20 feet of dark shale. This coal may represent the Bakerstown horizon. It is apparently limited in extent as other holes in the vicinity fail to record any coal at this horizon.

Coal in the Allegheny Group

UPPER FREEPORT COAL

The Upper Freeport coal is preserved in the Worthville syncline from Knoxdale southwestward to the southern edge of the quadrangle. It occurs in hilltops and has been mined commercially, but it is now very largely mined out. A few small patches occur in the Fairmount syncline west of Summerville.

The Upper Freeport coal maintains its best development in the Knoxdale-Ramsaytown district. This coal is locally called the Lower Freeport coal and has been mined and sold as such for years, but the writer is convinced, for the reasons given previously on pages 31-34, that this coal is the Upper Freeport.

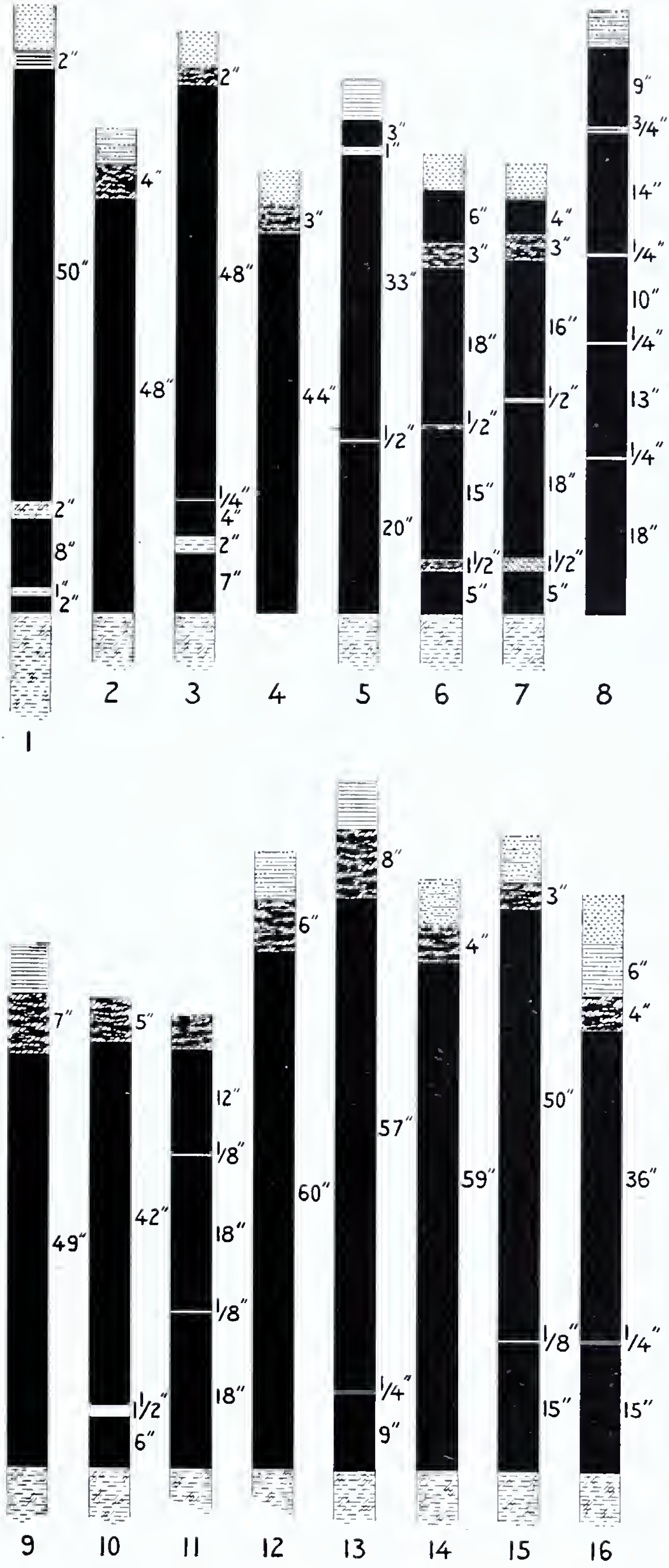
The Upper Freeport coal is rather persistent and is generally present wherever it has not been removed by erosion. It is usually between 4 and 5 feet thick, although as much as 8 feet of coal was observed in the Brosius country bank (Ad2) west of Summerville. The Upper Freeport coal usually has a layer of bony coal at the top from 3 to 8 inches thick. The roof may be shale or sandstone. The shale is usually thin and immediately overlain by a massive sandstone, the Mahoning, which frequently 'rolls down'' and cuts out part or all of the coal. This is observed in the mines and also is known from many drill records in the Ramsaytown-Knoxdale district. These barren areas have the character of old erosion channels and are called ''faults'' by the miners. They are not true faults in the sense that the coal has been cut out by movement of the beds along a plane or zone, but are local erosional unconformities. This cutting out of the Upper Freeport coal by sandstone is revealed by core drill holes (Ee 12 and 13) on the Smail farm south of Ramsaytown where, in one hole (Ee13), 157 feet of sandstone occupies an interval that apparently extends from 299 to 142 feet above the Lower Kittanning coal and, thus, down below the Lower Freeport horizon.

The Upper Freeport coal is soft and friable. It is recovered as about 50 percent lump and 50 percent slack. It commonly reveals thin bands of alternating bright lustrous and dull coal. Frequently a hard slaty binder near the floor is hard to clean from the coal and adds to the percentage of ash. A low but variable percent of sulphur is scattered through the coal.

Analyses from different parts of the quadrangle indicate an average composition of about 3 percent moisture, 34 percent volatile matter, 52 percent fixed carbon, 9 percent ash, and 2 to 3 percent sulphur. The coal is suitable for railroad, steam and domestic purposes but the available tonnage is limited.

Sections of the Upper Freeport coal are presented in figures 22 and 23.

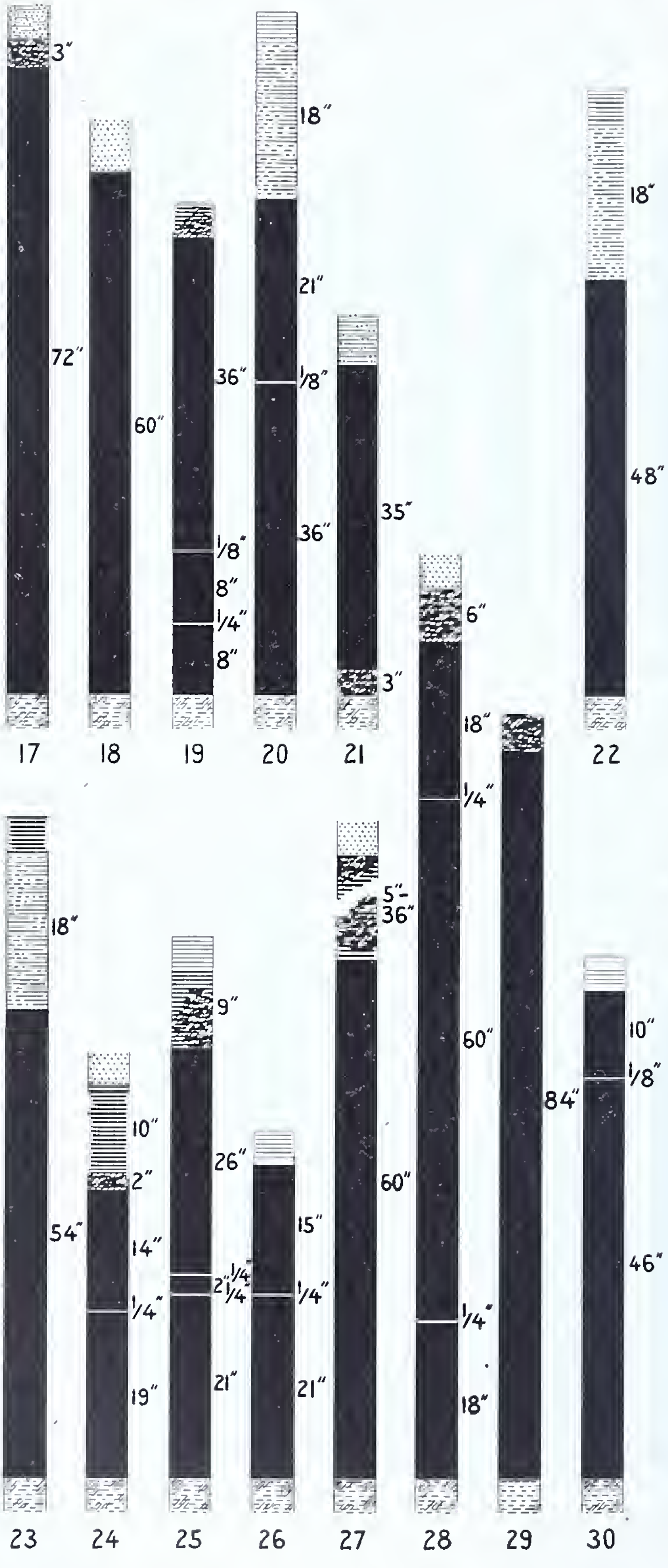
Knoxdale-Ramsaytown district. The largest and best developed area of Upper Freeport coal in the quadrangle is in the Knoxdale-Ramsaytown district, in the Worthville syncline, where the coal crops in the hills well above drainage. The coal occurs in a number of irregular-shaped areas, the largest of which includes the area from Pleasant Hill School, north of Knoxdale, to Ramsaytown and Cool Spring. In this area most of the commercial mining took place, but the coal is now largely mined out and only a few small mines and country banks remain to take out what is left. The other areas are small hilltop remnants and in these the mines were necessarily small and short-lived.



1. Ed1, Yates country bank, Swinefert farm. 2. Ed2, Stewart No. 1 mine. 3. Fd3, Wolferidge mine. 4. Ed3, country bank. 5. Ed4, country bank. 6. Ed5, Ramsay B. mine. 7. Ee1, Ramsay No. 2 mine. 8. Ee5, country bank. 9. De1, S. H. Renninger bank. 10. Ee6, Ramsay No. 4 mine. 11. De3, country bank. 12. De4, Bob Hamil country bank. 13. De5, Felicetti country bank. 14. De6, Galbraith country bank. 15. De7, Hines country bank. 16. De8, country bank.

Letters and numbers indicating locations refer to small rectangles on the Mineral Resources map; capital letters to north-south rows of rectangles, small letters to east-west rows, numbers to specific locations.

Figure 22. **Selected sections of the Upper Freeport coal in the Brookville quadrangle.**



17. De9, Helena mine. 18. Ee7, country bank, Geers farm. 19. Fc2, Yates country bank. 20. De10, Yaney country bank. 21. De11, country bank. 22. Ce1, Pifer and Kuntz country bank. 23. Ce2, Reitz country bank. 24. Cf2, C. B. Martz country bank. 25. Af1, country bank. 26. Af2, C. L. Martz country bank. 27. Ad1, Anderson country bank. 28. Ad2, Brosius country bank. 29. Ad3, Yancy country bank. 30. Ad4, O'Connor country bank.

Figure 23. Selected sections of Upper Freeport coal in the Brookville quadrangle.

Three high hills between McAninch School and Tait and Colon are probably high enough to contain the Upper Freeport coal, but as no crops or openings were observed the crop line is indicated on the map as a broken line.

However, the Upper Freeport coal is mined for local domestic use on the Swinefert farm at the Yates country bank (Ed1) in the hill immediately to the east. Here the coal is 5 feet thick with a sand rock roof (section 1). The coal rises to the northwest along the main entry. The Upper Freeport coal is also being mined in a small country bank in the hill to the south. The coal is rather croppy.

The Upper Freeport coal crops along the road about half a mile west of Pleasant Hill School. The coal in this hill was taken out of two mines by the Stewart Coal Company: Stewart No. 3 and Stewart No. 2. Stewart No. 3, (Fd1), a drift mine, was opened about 1913 and abandoned about 1918, during which time it produced 226,522 tons. The Swan Coal Co. reopened the mine in 1920 as the Swan No. 1 mine and operated it until 1924 when it was abandoned. The Swan mine produced 62,146 tons. The coal had a thickness of 5 feet including a 2-inch binder of bone and coal about 6 inches above the bottom. The roof is rolly, and in places the coal thins out and sandstone comes in contact with coal. The bottom was fire clay about 2 to 3 feet thick and of unknown commercial value.

Along the same side of the hill, a little farther south, is the now abandoned Stewart No. 2 mine (Fd2) of the Stewart Coal Co. It operated from about 1912 to 1918, during which time more than 364,000 tons were produced.

In the long narrow hill along which the road runs from Pleasant Hill School to Knoxdale, the Upper Freeport coal occurs in a narrow area near the hilltop. The coal has been mined in several small mines and country banks. The most recent operation is the Wolferidge mine (Fd3) of the Wolferidge Coal Company. The cap rock is sandstone underlain by a few inches of bone coal. The bed shows 4 feet of solid coal, below which the bottom coal is more or less split by binders. See Section 3. It is a small mine with a daily capacity of about 300 tons. This mine was opened in 1928 and up to 1931 had produced 54,302 tons, but has been practically idle since then.

The crop line may be traced along the hillside north of Knoxdale westward to Tait and Ramsaytown. It crosses the road about half a mile west of Knoxdale at an elevation of about 1,620 feet and follows the hill about a mile where it turns north and recrosses the road a mile west of Knoxdale. Here a country bank (Ed3) revealed 44 inches of coal and 3 inches of bone. See section 4. Massive sandstone cuts out much of the coal in places.

Continuing around the hill to the north to Ramsaytown the crop is marked by abandoned mines. In the vicinity of Ramsaytown the Upper Freeport coal was formerly extensively mined by the Shawmut Mining Company. The company has abandoned the mines and withdrawn from the field, since the larger areas of the coal are exhausted. A few small mines or country banks still yield some production, mainly for local consumption. Ramsaytown, once a bustling mining town, has become almost a deserted village. Sections 6-10 are from mines in this vicinity. The coal averaged about 4 feet thick.

Ramsay Coal Company opened the Ramsay B mine in 1920 north of Ramsaytown and operated until 1929. The maximum annual production was 35,833 tons in 1927. The coal section is shown in Figure 22, No. 6. The cap rock was gray sandstone 30 to 40 feet thick and the coal parted freely. The coal was medium hard, with a dull luster and produced about 60 percent lump and 40 percent slack. The impurities included bone, binder, and sulphur, which were cleaned by the miner. The floor was fire clay about 3 feet thick. The average output per day in 1924 was 75 tons.

The Shawmut Mining Company of St. Marys operated mines on the Upper Freeport in the vicinity of Ramsaytown from prior to 1909 until 1928. The mines have been abandoned since then, the coal having been practically exhausted. Sections of the coal are shown in Figure 22 from Ramsay No. 2 mine (Ee1) and Ramsay No. 4 mine. In Ramsay No. 2 mine the coal was immediately overlain by gray sandstone 30 to 40 feet thick. The coal was medium hard, had a dark luster and columnar fracture. It was underlain by 1 to 5 feet of fire clay. It is now exhausted and the acreage mined out is reported as 613 acres.

Ramsay No. 4 mine (Ee6) was likewise abandoned in 1928. The coal section is shown in figure 22, No. 10. The cap rock is sandstone and shale and the floor is fire clay ranging from 3 to 5 feet thick. Bony coal 5 inches thick immediately above the coal was rather persistent throughout the mine. Sulphur bands were scattered irregularly through the coal which was otherwise rather free of impurities except for one hard binder near the bottom. This binder was cleaned from the coal by hand. The coal broke down into approximately 50 percent lump and 50 percent slack. The average output in 1924 was 900 tons per day with about 90 percent recovery. Analysis of the coal* showed from 2.0 to 2.7 percent moisture, 34.8 to 35.4 percent volatile matter, 50.8 to 51.9 percent fixed carbon, 11.1 to 11.3 percent ash, and 3.2 to 3.5 percent sulphur. The B.t.u. value was 12,900 to 13,150 and the softening temperature of the ash was 2190° F.

In the hill about 1 mile west of Ramsaytown is a small mine (De1) of the Renninger Coal Co. in which a section of the coal shown in figure 22, No. 9 was obtained. The coal averages 49 inches in thickness, immediately on top of which is 7 inches of bony coal. This is a small operation which is taking out a limited area of coal. Only pillars are left and the coal is shipped as run of mine. About 15 tons per day are mined. Analysis of the coal (air-dried) shows 1.3 percent moisture, 35.7 percent volatile matter, 57.8 percent fixed carbon, 5.2 percent ash, and 1.1 percent sulphur. The B.t.u. value was 14,150 and the softening temperature of the ash was 2450° F.

Southwest of Ramsaytown the hilltops contain small areas of Upper Freeport coal which has been mined in small country banks. Coal sections from some of these are shown in figure 22. In the Galbraith bank (De6), the coal was 5 feet thick with several binders; it had a shale roof and 4 feet of fire clay on the bottom.

Along the road east from Millen School, in the Felicetti country bank, the Upper Freeport coal measured 5 feet, 6 inches (figure 22, No. 13) with 8 inches of bony coal on top. Similar sections were revealed in the neighboring Bob Hamil country bank (De4) and the Himes country bank (De7). See figure 22, Nos. 12 and 15.

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* Bituminous Coal Fields of Pennsylvania, Part IV, Pennsylvania Topog. & Geol. Survey, p. 99, 1928.

Just west of the State highway and about midway between Miller School and Cool Spring is the Helena mine (De9) of the Anita Coal Company where the Upper Freeport coal measures 6 feet in thickness. See Figure 23, No. 17. Here the coal is topped by 3 inches of bone. The roof is sandy shale.

Farther sorthwest toward Worthville isolated patches of Upper Freeport coal in the higher hills were mined out by small country banks for local use. Sections from the Yaney bank (De10) near Cliff School and another small bank (De11) are shown in Figure 23, Nos. 20 and 21. In the hill between Reitz Run and Ferguson Run the Upper Freeport coal was mined in the Pifer and Kuntz bank (Ce1) and the D. E. Reitz bank (Ce2), sections of which are shown in figure 23.

The Upper Freeport coal crops out south of Knoxdale between the village and the railroad station. Several small mines, among them Campbell No. 1 and Stewart No. 7, mined some coal from this locality. These mines are now caved and abandoned. The coal may be seen in outcrop in the Pittsburg & Shawmut Railroad cut at the south end of the tunnel west of Knoxdale, where the following section was obtained:

	Feet
Olive sandy shale and shaly sandstone	30
Coal	5
Fire clay	5
Gray sandy shale weathering to sandy clay	9
Gray sandstone	2
Gray sandy shale	8

Farther south along the valley of Indiancamp Run the Upper Freeport coal was observed in a country bank on the Geer farm about half a mile west of Green Valley (Ee7). Here the coal ranged from 4½ feet to 5 feet 8 inches in thickness with many thin partings. The roof was sandstone and frequently rolled down, reducing the thickness of the coal. The floor was fire clay.

The Upper Freeport coal horizon undoubtedly is present in the hills forming the southeast wall of the Indiancamp Run. No openings or outcrops were observed. It is believed that the coal is here either very thin or cut out by the overlying Mahoning sandstone.

Southeast of Knoxdale the high hills in the vicinity of Center Hill School contain the Upper Freeport horizon. The coal is apparently thin except at the eastern border of the quadrangle where, in the Yates mine (Fe2), 4 feet, 4 inches of good coal were measured.

Southern townships. South of Little Sandy Creek the Upper Freeport coal is present, but as yet it is little developed. East of Big Run the crop could not be accurately located but was mapped by an interval below what is believed to be the "summit lime," which occurs about 40 to 50 feet above the Upper Freeport coal north of Little Sandy Creek. The presence of springs and very thin coal on some local farms indicate the Upper Freeport is present but probably much thinner than north of Little Sandy Creek.

West of Big Run in Ringgold Township is a rather large area in which the Upper Freeport coal is undoubtedly present. No large mines have been opened here. Only a few country banks give some idea of the thickness of the coal. This is the only large area of probable minable Upper Freeport coal remaining in the quadrangle. Along Cherry Run, coal has been mined in a number of small country banks. It is locally called the "4-foot vein." The evidence is not conclusive but the author believes that it is the Upper Freeport and has so mapped it. At the C. B. Martz bank about a mile southeast of Weaver School this coal was 33 inches thick capped by 2 inches of bone, 10 inches of carbonaceous shale, and massive sandstone. This would indicate that the Upper Freeport coal is much thinner here but still of minable thickness.

Farther to the southwest, near the southern boundary of the quadrangle, the Upper Freeport coal is somewhat thicker but reveals a section similar to those shown in figure 23, Nos. 25 and 26, obtained in two country banks (Af1) and the C. L. Martz bank (Af2). Limestone occurs below and within a few feet of the coal in this vicinity. The section in country bank (Af1) reveals a lower bench 21 inches thick, the lower 4 inches of which is hard. The upper bench, 26 inches thick, has a diced fracture. The coal splits into horizontal thin layers and closely resembles the Upper Freeport coal at Ramsaytown. The upper 9 inches of the section is mixed carbonaceous shale and coal, above which is the shale roof. The floor is fire clay.

In the extreme southeastern corner of the quadrangle, in McCalmont Township, are a few outliers of the Upper Freeport coal of the Punxsutawney field, which is extensively developed a few miles to the southeast. In this area the Lower Freeport coal is the thicker coal and small country banks have been opened on it. The Upper Freeport coal was not seen, but its crop and presence is indicated about 40 to 50 feet above. One mile east of the quadrangle the Upper Freeport coal was observed in a small country bank in the hillside north of Battle Hollow where the following section was obtained:

	Ft.	in.
Drab shale	1	—
Carbonaceous shale, coal and bone	—	7
Coal	—	4
Binder	—	¼
Coal (shiny black)	2	2
Bony coal	0	4
Hard fire clay	—	

Summerville. The only other area of the Upper Freeport coal is west of Summerville, where some of the higher hills in a structurally low basin of the Fairmount syncline contain the coal. The area is limited and hence the coal has been mined only in small country banks. Several sections of the coal obtained in this district (as shown in figure 23, Nos. 27, 28, 29, 30) indicate that the Upper Freeport coal here reached magnificent thicknessess. In the Brosius bank (Ad2) the coal measured 8 feet in many places. In the Yaney bank (Ad3) it averaged 7 feet. It is unfortunate that nearly all the Upper Freeport has been removed by erosion in this region where it was so thick.

In the Reed mine, 2 miles northwest of Summerville, a section obtained by the U. S. Bureau of Mines in 1924 showed an upper bench 1 foot thick and a lower bench of coal 3 feet 9¾ inches thick, separated by 1 inch of bone. The roof was slate and the floor fire clay. The analysis of this coal, air dried, shows moisture 1.1 percent, volatile matter 36.3 percent, fixed carbon 52.1 percent, ash 10.5 percent, and sulphur 2.7 percent. B.t.u. value was 13,240 and the softening temperature of the ash 2240° F.

LOWER FREEPORT COAL

As previously stated in this report, apparently only one Freeport coal in the Brookville quadrangle is of minable thickness with the exception of the extreme southeast corner. The Second Geological Survey of Pennsylvania presented sections in this region which include both the Upper and Lower Freeport coals and indicate minable thicknessess. Evidently the same coal was reported sometimes as Upper Freeport, sometimes as Lower Freeport. Many drill records in the Worthville syncline show only one thick coal. This coal, as stated previously, has been called Lower Freeport by the companies and is so recorded in all previous reports of this Survey. For reasons stated at some length on pages 31-34 of this report, the writer prefers to regard this coal as Upper Freeport. Hence, there is no Lower Freeport anywhere in the quadrangle of any prospective importance. At many places, and in many records, a thin showing of coal is noted about 50 feet below the thick, minable coal. This represents the Lower Freeport horizon. No crops anywhere indicated thick coal at this horizon.

The exception to this statement is a small area in the extreme southeastern corner of the quadrangle in McCalmont Township, which is really a part of the Punxsutawney field. Here both Freeport coals are developed to minable thickness. In the hill south of B. M. 1631, Parker Nichols has two coal banks on what is probably the Lower Freeport coal. Sections measured here follow:

Parker Nichols coal banks

North side of hill (Ff1)

	Ft.	in.
Thin-bedded sandstone roof		
Carbonaceous shale and bone	0	7
Coal	4	7
Fire clay floor		

South side of hill (Ff2)

	Ft.	in.
Shaly sandstone roof		
Carbonaceous shale and bone	0	10
Coal (hard)	0	10
Coal (friable)	1	5
Binder	0	1
Coal	1	10
Fire clay floor		

In the hill east of Worthville a coal bed which occurs approximately 175 feet above the Vanport limestone has been mined by the farmers for house use. Where observed (Df2) it was 3 feet thick. Above the opening was a ten-foot cliff of thin-bedded sandstone. This is probably the Lower Freeport coal although it may be the Upper Kittanning. It does not appear to be persistent over any great area.

In the Fairmount syncline west of Summerville, the Lower Freeport coal was observed in several places in thin crops about 40 feet below the Upper Freeport. Wherever prospected it has proved to be too thin and too inferior in quality to be worked.

UPPER KITTANNING COAL

Thin coals occur at several horizons between the Lower Freeport coal and the Middle Kittanning coal. In some places the horizon is represented by black shale. The horizon about 110 feet below the Upper Freeport probably represents the Upper Kittanning coal in this quadrangle. No evidence, either in drill records or in outcrop, would indicate any prospect that the Upper Kittanning coal is developed to minable thickness anywhere within the quadrangle.

MIDDLE KITTANNING COAL

The Middle Kittanning coal lies approximately 140 feet below the Upper Freeport coal and 55 feet above the Lower Kittanning coal. Its thickness and quality are extremely variable. It is thickest in southern Rose and Knox Townships and northern Oliver Township in an area extending from Stanton to Knoxdale and southward to East Branch on Little Sandy Creek. It ranges from 2 feet 10 inches to 4 feet 2 inches in thickness. In composition, the Middle Kittanning coal varies from 29 to 34 percent volatile matter, 48 to 55 percent fixed carbon, 7 to 12 percent ash, and 1 to 3 percent sulphur. Sections of the Middle Kittanning coal are shown on figure 24.

The Middle Kittanning coal is mined in Rose Township at McGarey No. 1 mine (De12) about 1 mile south of Stanton. This was formerly the Cherokee mine of the Cherokee Mining Company (1919-1924). The coal occurs in two benches separated by about one inch of shale parting. The top bench is 12 to 16 inches thick and the bottom bench is 17 to 26 inches thick. Below this is 2 to 4 inches of carbonaceous shale underlain by sandy fire clay (See figure 24, section 7). The parting in the middle of the bed is persistent and characteristic of the Middle Kittanning coal. The coal has a bright luster, fine-banded texture, and is medium hard. The presence of bony bands and sulphur streaks makes the coal hard to clean. It is shipped as run of mine.

The Middle Kittanning coal was mined in the hillside east of Stanton in the Stanton No. 2 mine (Dd1) from 1918 to 1924. The production was 36,953 tons in 1920, but in 1924, the last year of working, the production was only 1,200 tons. Here the bed is in three benches which in ascending order are 19, 4, and 20 inches thick, separated by half inch shaly binders (See figure 24, section 6). The same coal was mined in several small banks in the next hill to the east where it is said to occur in two benches and to be dirty and sulphurous.

The principal mining district was south of Knoxdale along Indiancamp Run. From 1916 to 1927, five commercial mines operated on this bed at various times. These mines were the Colonial mine of the Sebring Coal Company (Fc6), Stewart No. 5 of the Stewart Coal Company (later known as Ray No. 5 and Loash No. 1), the Green Valley No. 1 mine of the Green Valley Coal Company (Fe5), Campbell No. 2 of the Knoxdale Coal and Coke Company (Fe4), and East Branch No. 1 of the East Branch Coal Company (Ef1). Coal sections from these mines are shown on figure 24. The bed occurs in two or three benches separated by a bony parting up to 6 inches in thickness. In the immediate vicinity of Knoxdale the top bench is 8 to 10 inches thick and is separated from a middle bench, 12 to 19 inches thick, by a bony parting 1 to 6 inches thick. The bottom bench is 5 to 8 inches thick, and is separated from the middle bench by a sulphur and bone parting 1½ to 2 inches thick. The coal is therefore hard to clean, and the product is dirty and high in ash. One mile south of Knoxdale the bed is in two benches, of which the upper one is 10 to 12 inches thick. It is separated from the bottom bench, 20 to 28 inches thick, by a bony parting 2 to 4 inches thick. The Middle Kittanning coal is not by any means exhausted in this district, but at present is not being mined on account of its inferior quality and the difficulty and expense of obtaining clean coal to compete with higher grade coals of the district. It is a potential source of future coal.

At the East Branch No. 1 mine (Ef1) in Oliver Township, 2 miles east of Cool Spring, the Middle Kittanning coal was mined with an average thickness of 3 feet 6 inches. See figure 24, section 4. This mine is now exhausted and was abandoned in 1925. At present some Middle Kittanning coal is mined in country banks for local household consumption. Northeast of Knoxdale the Middle Kittanning coal appears to thin rapidly. It was observed in two country banks (Fd4 and Fd5) in a single bed 18 inches thick.

In other parts of the quadrangle the Middle Kittanning coal is sporadic in occurrence. It is frequently too thin for mining or the horizon is marked by black shale.

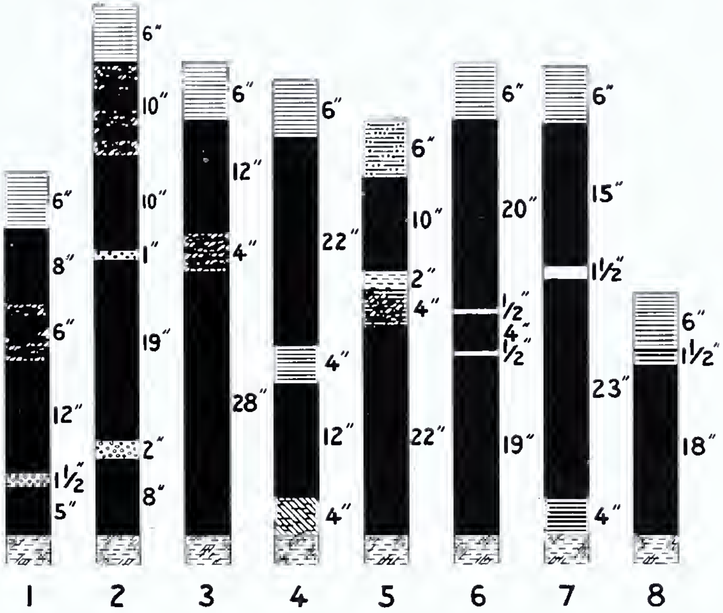

Figure 24. Selected sections of the Middle Kittanning coal in the Brookville quadrangle.

1. Fe3, Shetland No. 1 mine (formerly Ray No. 5 or Stewart No. 5). 2. Fe4, Campbell No. 2 mine. 3. Fe5, Green Valley No. 1 mine. 4. Ef1, East Branch No. 1 mine. 5. Fe7, small mine. 6. Dd1, Stanton No. 2 mine. 7. De12, McGarey No. 1 mine. 8. Fd4, country bank.

In Rose Township, between Crate School and Stanton, the Middle Kittanning coal has been prospected by the farmers for their own use. It is reported 2 to 3 feet thick, but the old banks are all caved. The coal crops near the top of the high hills along the highway to Punxsutawney about 2 miles south of Crate School. Here it is 2 feet thick in a double bed separated by a thin shale parting. The height of the timbers at the caved banks would indicate a thin coal. A churn drill hole on the Jonathan Reitz farm (Ce3) in Beaver Township records 2 feet 2 inches of coal at this horizon. Other holes nearby fail to record any coal. On the Gil Reitz farm (Dd2) in Rose Township, north of Stanton, a churn drill hole records a double coal bed at this horizon showing 2 feet 8 inches of coal in the upper bed separated by 6 feet of shale from a lower bed of coal 2 feet thick.

Between Ohl and Thomas School in Beaver Township, the Middle Kittanning coal was observed in several outcrops, indicating a thickness of 18 inches to 2 feet of coal.

The Middle Kittanning coal is apparently unimportant in the valley of Redbank Creek. Several diamond drill holes of the Hanley Ceramics Company north of Summerville show 14 to 16 inches of coal about 21 feet above the Lower Kittanning coal. This may be the Middle Kittanning. In the vicinity of Holden and Corsica the Middle Kittanning coal has been opened in country banks in several places near the tops of the hills. A blossom along the road northeast of Holden would indicate about 2 feet of coal. However, the area underlain by the coal is limited to small patches in the hilltops.

The Middle Kittanning coal is reported as 3 feet thick in Union Township in the report on Jefferson County by W. G. Platt of the Second Pennsylvania Geological Survey. It was reported to be mined in several places in the vicinity of Corsica and Roseville. It should be noted here that no such development of the Middle Kittanning coal was observed in this area and the probability is that it was confused through lack of detailed structure mapping with the Lower Kittanning coal which is persistent and minable here.

LOWER KITTANNING COAL

The Lower Kittanning coal is preserved throughout most of the quadrangle. It is more persistent than any other coal bed of the Allegheny group. The horizon of this coal occupies the broad uplands of the quadrangle except for the areas of the Worthville syncline and the Fairmount syncline west of Summerville. The coal is best developed in the region between Summerville and Corsica and north of Roseville in Clover and Union Townships. It is also well developed near Stanton and Ramseytown in Knox Township and along Indiancamp Creek and near Markton in Oliver Township.

As mentioned before, the Lower Kittanning coal is sometimes called the ''30-inch vein'' because of its persistence and average thickness of 30 inches. The thickness of the coal in the quadrangle ranges from 18 inches to 4 feet, the latter thickness being observed in the mine of the DeHaven Coal Company west of Corsica (Ab3). Because thicknesses of three feet or more are rare, there has not been much commercial exploitation of this coal. However, it has been more extensively mined for local consumption than any other bed in the quadrangle, small drifts and country banks supplying most of the house coal in the region.

For the most part, the Lower Kittanning coal is one solid bed. Occasionally there is a binder less than one inch thick which appears from 6 to 12 inches below the top of the coal. This binder is 3 inches thick at the Sutton No. 10 mine at Sutton (Ac4). Occasionally the bed splits. Two thin coals at the horizon of the Lower Kittanning coal were dug along the east side of Indiancamp Run in Oliver Township. Two coals have also been reported from prospect holes nearby. The coal "rolls" considerably. Stripping operations on the Lower Kittanning coal at Corsica and south of Brookville show this feature. At some places the coal bed rolls 25 feet in a very short distance. The coal lies 30 to 50 feet above the Vanport limestone, which is an excellent marker when present, and 190 to 225 feet below the Upper Freeport coal.

The Lower Kittanning coal almost always has a roof of thin-bedded, buff-colored shale. Occasionally there is 4 to 6 inches of bony coal immediately below the roof. At the Thrush coal bank near Stanton (Dd3) the roof is sandstone, and at one or two other small banks the roof is sandy shale. The coal is underlain at all places by fire clay which ranges from 3 to 20 feet thick. The upper 3 or 4 feet consists of good plastic clay that in many places may be developed on a commercial scale. This clay is worked by the Hanley Ceramics Company at Summerville.

The Lower Kittanning coal in the quadrangle is soft and friable and, when mined, breaks up into small pieces. The coal has a dull lustre and an irregular cubical cleavage. Several analyses of the coal show these average figures, in percent: Moisture 3, volatile matter 33-37, fixed carbon 46-57, ash 6-14, sulphur 0.9-3.

The coal is suitable for steam and domestic purposes.

Sections of the Lower Kittanning coal are shown in figures 25, 26, and 27.

The greatest commercial development of the Lower Kittanning coal has taken place in the Holden-Corsica-Roseville district in the northwestern part of the quadrangle, mostly in Union Township. The coal has been mined here quite extensively but probably a considerable area of good coal remains to be removed. The thickness of the coal in this area averages 38 inches, the greatest thickness reached anywhere in the quadrangle. At the operation of the DeHaven Coal Company, one mile north of Corsica (Bb2), 42 inches of coal was observed. A half inch binder lies 9 inches below the top of the coal. The roof is shale. At another operation of the DeHaven Coal Company one mile west of Corsica (Ab3) the coal is 46 inches thick without any binders. At the Pawnee mine, half a mile northeast of Holden (Ab2), the coal is 40 inches thick with two quarter-inch binders 13 inches from the top and 15 inches from the bottom of the coal.

The Barrett and Corbett stripping near Roseville (Cb2) worked on 40 inches of the solid coal which was overlain by 4 inches of bony and carbonaceous shale. At the Corbin country bank No. 2, one mile north of Roseville (Cb6), the coal was observed to be 40 inches thick with a quarter inch binder 12 inches from the top. Numerous other small mines and country banks in the L shaped area from Holden to Corsica to Roseville show similar thicknessess of the Lower Kittanning coal (See fig. 25).

In the northeastern part of the quadrangle, in Eldred, Warsaw, Pine Creek, and part of Rose Townships, the Lower Kittanning coal is largely missing, having been eroded by the waters of North Fork and its tributaries, or being too thin to work. Between the villages of Alaska and Howe along the Sigel road four small hills carry the Lower Kittanning coal. In each of them one or two small country

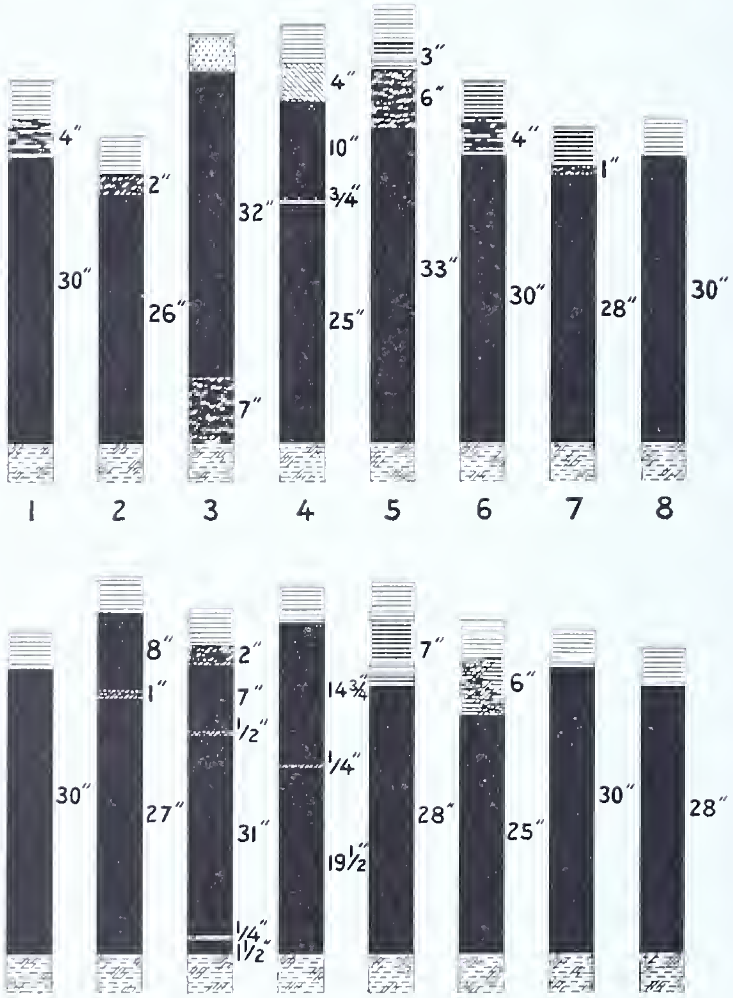

Figure 25. Selected sections of the Lower Kittanning coal in the Brookville quadrangle.

1. Dc1, R. A. Beckman bank. 2. Dc2, country bank. 3. Dd3, Thrush's coal bank. 4. Ed6, Hilltop mine. 5. De13, McGarey No. 2. 6. Dd5, S. H. Renninger bank. 7. Cc1, country coal bank. 8. Cd1, Leslie Shields bank. 9. Bd1, country coal bank. 10. Bc1, Pennsy No. 5 mine. 11. Bd2, Pennsy No. 6 mine. 12. Ac2, Reed mine. 13. Bd3, Stahlman bank. 14. Ad7, Blotzer coal bank. 15. Ce5, country bank. 16. Ce6, Norman Geist bank.

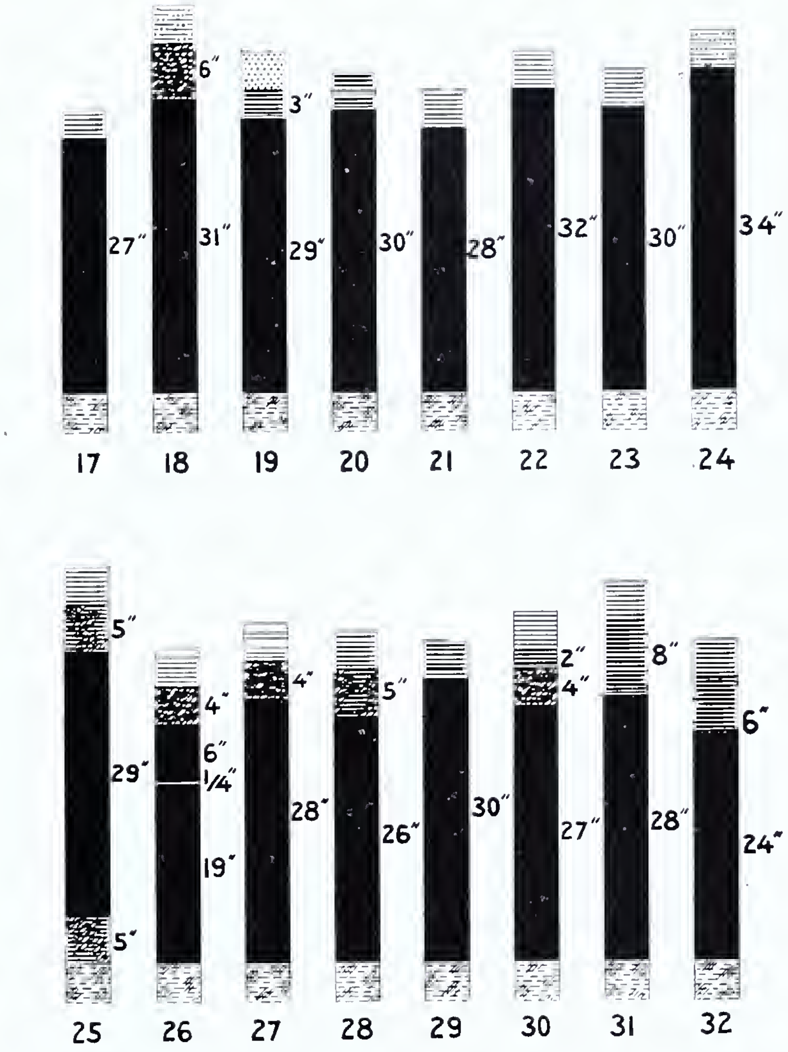

Figure 26. **Selected sections of the Lower Kittanning coal in the Brookville quadrangle.**

17. De14, C. F. Hoffman bank. 18. Ee15, Peterson coal bank. 19. Ef2, country coal bank. 20. Fe8, Shetland No. 2. 21. Ee16, East Branch No. 5. 22. Ef3, East Branch No. 2. 23. Af3, Clyde Shick bank. 24. Bf1, Snyder bank. 25. Bf2, country bank. 26. Cf3, John Stormer bank. 27. Cf4, Blake Geist bank. 28. Df3, Hawthorne bank. 29. Ef5, Markton Coal Co.—Oliver mine 30. Ef6, Kougher coal bank. 31. Ef7, Machob coal bank. 32. Ff3, Lucy Means bank.

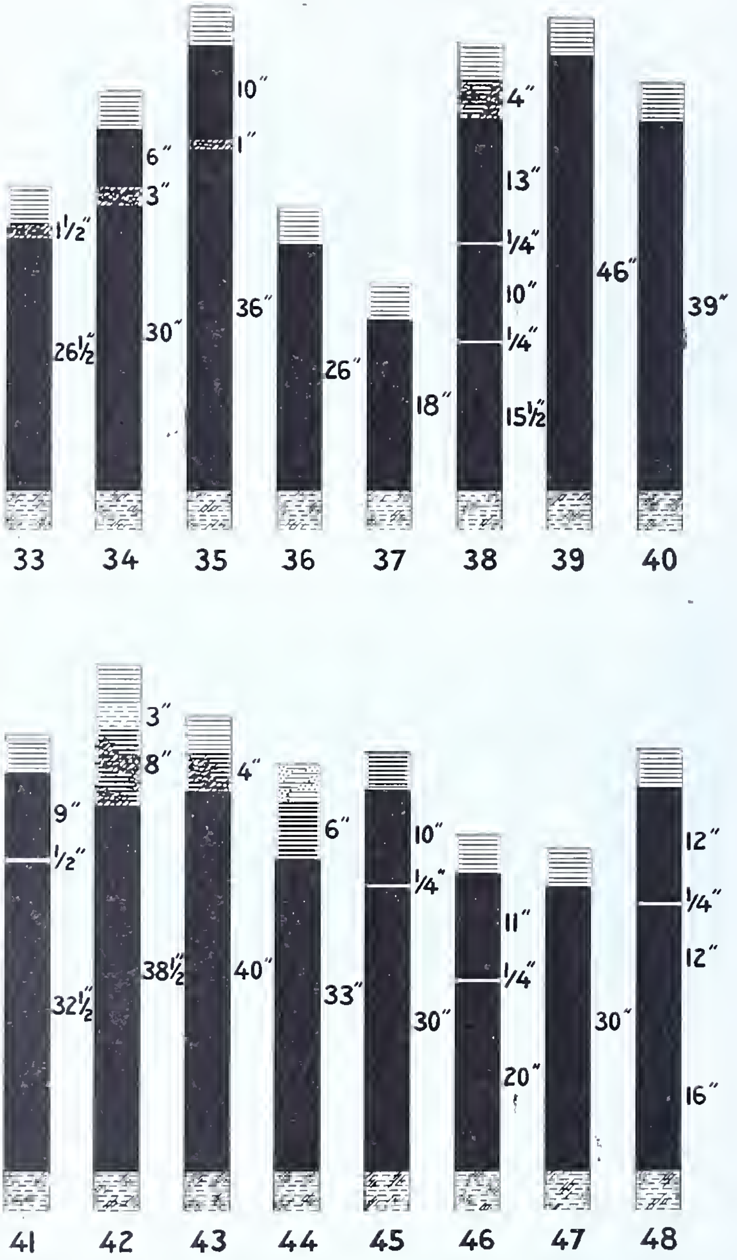

Figure 27. **Selected sections of the Lower Kittanning coal in the Brookville quadrangle.**

33. Ac3, Pennsy No. 7. 24. Ac4, Sutton No. 10. 35. Ac5, Williams mine. 36. Cc2, country bank, Knapp farm. 37. Cc3, country bank. 38. Ab2, Pawnee mine. 39. Ab3, DeHaven Coal Co. 40. Bb1, Pawnee mine. 41. Bb2, DeHaven Coal Co. 42. Bb3, Sills coal bank. 43. Cb2, Barrett & Corbett stripping. 44. Bb4, George Winters coal bank. 45. Cb3, Triangle Coal Co. 46. Cb4, Cowan coal bank. 47. Cb5, country bank. 48. Cb6, Corbin country bank No. 2.

banks worked the coal at one time. At the northwestern edge of Brookville another small hill carries the coal; it has been taken out from a country bank just north of the main highway to Corsica. At Miller School, two miles northeast of the court-house at Brookville, the Lower Kittanning coal crops out in the adjoining hill. Several of the higher hills in Warsaw Township may carry the coal but it was not observed in the crop.

Half a mile south of Brookville, and along the flank of the hill at Matthews School, the Lower Kittanning coal was stripped during the fall of 1940. The coal is 36 inches thick and is overlain by black fissile shale. A country bank is opened on the same bed a quarter of a mile east and the coal is reported to be 30 inches thick.

Between Stanton and Brookville along the main road to Punxsutawney the Lower Kittanning coal has been dug in many places. Immediately south of Crate School in Rose Township the R. A. Beckman bank (Dc1) showed 30 inches of solid coal. A nearby country bank (Dc2) showed 26 inches of solid coal. Just north of Stanton the Thrush coal bank (Dd3) exposed 32 inches of solid coal underlaid by 7 inches of bony coal and overlain by a sandstone. The S. H. Renninger bank, not far away, showed 30 inches of coal without parting. Many other country banks have been opened and operated at one time on the Lower Kittanning coal in this area. There is still considerable coal that can be removed.

South of Stanton the McGary No. 2 mine operated on 33 inches of coal. A large hill west of here and extending northward to Conifer carries the Lower Kittanning coal. Several country banks have been worked there.

In Knox Township the Lower Kittanning coal is deeply buried in the southern part because of the Worthville syncline which has depressed the formations. Half a mile southeast of Pawnee School the coal crops out in a hill and has been mined at the Hilltop mine (Ed6). Here the coal averages 35 inches and carries a small binder 10 inches below the top. Near Cool Spring and along the valley of Lick Run the Lower Kittanning coal crops out. The thickness ranges from 24 to 32 inches. A mile north of East Branch the East Branch No. 5 mine (Ee16) worked on 28 inches of solid coal. At the Shetland No. 2 mine (Fe8) just northeast of Green Valley the coal averages 30 inches. As mentioned before, the most important coal mined in this district is the Upper Freeport.

South of East Branch, and near Burkett Hollow School and Markton, the Lower Kittanning coal is well developed. At the Oliver mine (Ef5) of the Markton Coal Company, the coal is solid and averages 30 inches. The Kougher coal bank (Ef6) and the Machob coal bank (Ef7) nearby, show 27 and 28 inches of coal respectively, the former being capped with 4 inches of bony coal. The Lower Kittanning coal crops out on the valley flanks of Clutch Run. Here several local drifts have worked the coal which averages about 28 inches.

In the southernmost part of the quadrangle, the Lower Kittanning coal crops out along Little Sandy Creek and Big Run in Oliver Township; along Little Sandy Creek and its tributaries, Ferguson Run and Cherry Run, in Ringgold Township; and along Mudlick Creek in Armstrong County. Many small country banks have operated on the coal in this area from time to time. The coal ranges from about 25 inches in thickness with a small parting, as at the John Strimer bank (Cf3) near Worthville, to 34 inches of good solid coal, as observed at the Snyder bank (Bf1) not far from North Freedom. A small hill just south of Coleman School in Armstrong County, and another hill a mile west of the school both carry the horizon of the Lower Kittanning coal.

In Beaver Township a large area in the vicinity of Thomas School, and Zion School, south of Ohl, is underlain by the Lower Kittanning coal. The coal averages 28 to 30 inches in thickness and is free from partings. Many small banks have worked the bed, but considerable coal remains. A similar area lies immediately southwest of Conifer and is separated from this area by the small valleys of Reitz and Tarkiln Runs. An isolated area of three high hills southeast of Conifer carries the Lower Kittanning horizon.

In Redbank Township, Clarion County, the Lower Kittanning coal crops out along the valley of Pine Creek and its small tributaries from the edge of the quadrangle near Dinger School northward to Shannondale and Himes School. The coal averages 30 inches in thickness and lacks partings in most places. Frequently it is overlain by 5 or 6 inches of bony coal, as at the Blotzer coal bank (Ad7) north of Shannondale.

In Limestone Township, Clarion County, the Lower Kittanning coal is well developed. The region around Harlan and Sutton is a southern extension of the important region around Holden and Corsica. At the Reed mine (Ac2) near Harlan 34 inches of coal, with a thin binder 15 inches below the top, was exposed. At the nearby Pennsy No. 7 mine, 27 inches of solid coal was mined. At Sutton, the Sutton No. 10 mine worked on 36 inches with a 3-inch binder 6 inches below the top. Four hills south of Holden carry the horizon of the Lower Kittanning. On the largest hill the Williams mine opened a 46 inch bed of the Lower Kittanning which had a one inch binder 10 inches below the top.

In Clover Township the Lower Kittanning coal is best developed on the divide east of Harlan, between Runaway Run and Welch Run. Several mines and many country banks have removed the coal in this area. The Pennsy No. 5 mine (Bc1) exposed 35 inches of coal with a one inch bone binder 8 inches below the top. Four or five high areas between Redbank Creek and its tributaries, Welch Run and Cedar Run, carry the horizon of the Lower Kittanning coal. Numerous country banks in this area show the coal to average about 28 inches in thickness. One bank (Cc7) was opened on 18 inches of solid coal.

In the vicinity of Summerville and around Mt. Pleasant School, two miles east, eight hills carry the Lower Kittanning coal. The coal seems to be uniformly 30 inches thick where observed in the country banks that have worked or are working this coal. At Leslie Shield's bank (Cd1) the coal was 30 inches; at the Stahlman bank (Bd3) 28 inches, and at another bank (Bd1) 1¾ miles east the coal was 30 inches. Binders were not observed in this area and the coal was roofed by shale in every place. Just west of Summerville the Pennsy No. 6 mine (Bd2) worked 40 inches of coal which had a thin clay parting 2 inches from the bottom, a half-inch bony binder 7 inches below the top, and was capped by 2 inches of bony coal.

CLARION COAL

The Clarion coals are not commercially important in the quadrangle. The Upper Clarion coal, which lies 25 to 35 feet below the Vanport limestone, is not thick enough to mine anywhere except for personal use, a few country banks having been opened on 18 inches of coal. Many persons refer to the Upper Clarion coal as the "pencil mark" coal. The best exposure of this coal is in the railroad cut at Sutton. At Sutton 20 inches of Upper Clarion coal are split by a foot of shale directly in the middle. The upper 10 inches of coal are roofed by 25 feet of shale which occupies most of the interval to the Vanport limestone. The lower 10 inches of coal are underlain by 4 feet of fire clay. A short distance east in the railroad cut the horizon of the Upper Clarion shows a foot of coal. It is most persistent in the central part of the quadrangle.

The Lower Clarion coal is best developed in the same area as the Upper Clarion, throughout the central part of the quadrangle. It is usually too thin to have any economic value, but at a few places where it is 3½ feet thick it has been mined. Many country banks have worked on it. The Lower Clarion coal lies at an average interval of 40 feet below the Vanport limestone and 30 to 50 feet above the Brookville coal. The roof of the coal usually is shale but occasionally, as at the New Humphrey quarry just south of Brookville, the roof is sandstone. Beneath the Lower Clarion coal a good fire clay, which ranges from 4 to 12 feet in thickness, is always found. This clay is mined by the Hanley Ceramics Company at Summerville.

The Lower Clarion coal is of poor quality. It has a high sulphur content and often exhibits bands of sulphur "balls" and many bone partings. This is a contributing reason why the Clarion coal has little economic value.

The coal is hard and blocky. An average analysis of the coal shows: Moisture 3-4 percent, volatile matter 37-39, fixed carbon 46-52, ash 6-11, and sulphur 3-6 percent. The coal is suitable for domestic use.

Near Sutton the Lower Clarion probably has its best development in the quadrangle. The railroad cut east of Sutton shows 2½ feet of coal and the coal in a nearby country bank is reported to be more than 3 feet thick. At New Humphrey quarry near Brookville the Clarion coal is 20 inches thick. In the hill above Old Humphrey quarry two caved drifts mark the Clarion horizon. The coal is reported to have been 22 inches thick. An old drift on the Clarion coal at Tunnel Hill, south of Brookville, is reported to have been on 20 inches of coal. Two miles northwest of Baxter along Simpson Run in Clover Township the Lower Clarion horizon shows 39 inches of coal. Though not as persistent as the Lower Kittanning coal, the Clarion horizon can be determined over most of the quadrangle. Rarely does the coal reach a thickness of more than 18 inches except in the places mentioned above.

BROOKVILLE COAL

The Brookville coal is present throughout most of the quadrangle. Because it is at a lower horizon than the Lower Kittanning coal, erosion has not removed as much of it from the area. However, its thickness is not as persistent as the Lower Kittanning and in some places it is absent or very thin. The Brookville coal and underlying clay comprise the oldest and lowest stratigraphic member of the Allegheny group. The horizon lies about 85 feet below the Vanport limestone and 30 to 50 feet below the Clarion coal. Its horizon is characteristically located at the top of the steep-walled valleys of the quadrangle. The best development of the coal is in the vicinity of Conifer in Beaver Township. It is also well developed in parts of Clover, Rose, and Knox Townships. Near Brookville the coal has no commercial importance.

The Brookville coal ranges in thickness from 10 inches to 5 feet. An average of 4 feet of coal underlies the area near Conifer and Stanton and along Smathers Run in Rose Township. Usually the Brookville coal is one bed, but it has been reported as a split bed in the adjoining Smicksburg quadrangle. The bed usually carries one or two partings or binders. At Conifer a 2-inch bone and shale binder occurs about 12 inches below the top of the coal. Near Summerville there are two bone and pyritic binders which separate the bed into 3 benches. Except where the coal is thin there are binders in it. The coal is frequently thinned and completely eliminated by thickening of the overlying Clarion sandstone. The resultant irregularity in thickness is especially noticeable in the vicinity of Brookville, where the coal is thin, and in the northern and southern parts of the quadrangle. The coal is roofed by either shale or sandstone and is everywhere underlain by clay.

The presence of the bone, shale, and pyritic binders and a fairly high content of sulphur in the lower part of the coal bed decrease its value. It has been dug extensively for local domestic use and is suitable for use as a steam coal. Several analyses of the Brookville coal show the following average figures: Moisture 2-3 percent, volatile matter 34-36, fixed carbon 49-53, ash 10-13, and sulphur 3-5 percent.

The most extensive mining of the Brookville coal has taken place in the region around Conifer. The thickness of the coal ranges between 3 and 6 feet. At the Conifer No. 5 mine 47 inches of coal was mined by the Allegheny River Mining Company. This coal carries a thin shale and bone binder 12 inches below the top, and is overlain by shale. At the Conifer Nos. 1, 3, and 4 mines 51 inches of coal was mined. This, too, carries a small binder of shale 10 inches below the top. A foot from the bottom there is a one-inch bony binder, thus breaking the bed into 3 benches. Many country banks have been opened on the Brookville coal in this region beside other commercial operations. Though most mining activity has ceased, considerable coal remains, and of sufficient thickness to be mined commercially. However, the poor quality of much of the coal is a detrimental feature.

Considerable mining of the Brookville coal bed has also been carried on in the vicinity of Summerville in Clover Township. Here the Brookville bed has a total thickness of 5 feet. Again the bed is separated into two and three benches by partings. At the Dayton No. 10 mine at Summerville 51 inches of coal was mined. Ten inches of bony coal lie 8 inches above the bottom of the bed and a thin parting of bone lies 15 inches below the top. The roof is shale. At the Waldorf No. 2 mine, 1 mile northwest of Summerville, the coal is 44 inches thick and carries two thin bone binders 6 inches below the top and 22 inches above the bottom of the coal. At the Pleasant Grove mine nearby the coal is 51 inches thick and the ubiquitous bony binders are 3 and 4 inches in thickness. Both these mines have shale roofs and are floored with fire clay. At Sutton (Ac6) 4½ feet of coal were mined by shafting. Numerous banks have been opened on the coal near Harlan and along Runaway Run and much good coal remains.

The Brookville coal is best exposed in the railroad cut one mile southwest of Coder in Rose Township. The extreme variability of the Brookville member in this region has been described on p. 54. At the Coder No. 5 mine, at Coder, 48 inches of coal was mined. Two thin bone partings divided the bed into three benches. At the Viaduct mine, north of Baxter in Clover Township, 35 inches of fairly good coal was mined. This coal has only one binder one inch thick 9 inches below the top. The roof is bony shale. Country banks show the Brookville coal to average nearly 4 feet thick near Baxter.

There is also a fair development of the Brookville coal in Knox Township, especially near Pawnee School. At the Yates mine near here the coal is 56 inches thick with two thin binders near the top and bottom. The Pawnee mine exposed 59 inches of coal. Three thin partings make four benches at this mine. From the bottom to the top the benches are 11, 6, 30, and 12 inches thick. Along Sandy Lick Creek in Knox Township, the Brookville coal has been mined at many country banks. Apparently it thins toward the east, for the average thickness is about 36 to 40 inches.

In Pine Creek Township the Brookville coal is thin. However, it is as much as 40 and 45 inches thick in local areas and here it has been mined for local use.

North of Alaska, in northern Rose Township, the Brookville coal has been reported as 4 feet thick. Although this was not seen, the coal is mined at the Mineweaser mine northeast of Alaska and is 3 feet thick.

In Warsaw Township the coal is mined at several country banks for local use near Richardsville, where it is badly split and seldom more than 3 feet thick.

In the southern part of the quadrangle the Brookville coal is thin or lacking. Near Sprankle Mills in Oliver Township 2 feet of coal have been measured and less than 2 miles south of Sprankle Mills, in the Smickburg quadrangle, 40 inches of split coal is reported and several country banks are said to have worked on it.

In the immediate vicinity of Brookville the coal has no commercial value. It has been mined for local consumption in four small banks on Tunnel Hill in South Brookville. The horizon is identifiable all around Brookville but the coal is thin. At New Humphrey quarry the coal is 1 foot thick and at Old Humphrey quarry there are 15 inches of Brookville coal. It is strange that the coal which bears the name "Brookville" should have taken that name from an area where the coal is so thin and of such poor quality.

Coal in the Pottsville Series

MERCER COAL

The Mercer group of the Pottsville series is the only important coal-bearing group below the Brookville horizon. The massive Connoquenessing sandstone which underlies the Mercer sometimes carries a thin coal called the Quakertown, but this was not seen in the quadrangle. There are one, two, or three coals in the Mercer group, all variable in thickness. Nowhere in the quadrangle can the Mercer coals be considered thick enough or constant enough to have real commercial value. The Mercer coal is largely confined to the vicinity of Brookville and the northern part of the quadrangle, where it has been mined in many places for local use as house coal. At most other places in the quadrangle it is deeply buried and known only by occasional records of drill holes.

The Mercer coals occur from 110 to 150 feet below the Vanport limestone. The great variation in interval is due to the extreme variation of the Mercer group (or Mercer-Brookville group) itself.

The Mercer horizon is limited to the valleys where streams have exposed the Pottsville series. In addition to the erratic physical character of the Mercer coal where it is known, the chemical character is also variable. Generally, however, it is dirty and has a high ash and sulphur content.

In the northern part of the quadrangle and around Brookville there are usually two coals. The average thickness of the two coals near Brookville is 30 inches. Northward, toward Richardsville in Warsaw Township, the Mercer coal has an average thickness of 24 inches with a thinner seam "riding" above it. Along Welch Run, one mile north of Summerville in Clover Township, the Mercer was dug in a country bank and was 42 inches thick. This is probably the best local development of the Mercer coal in the quadrangle.

Along Mill Creek in Eldred and Mill Creek Townships, the Mercer again shows two coal horizons. Country banks have been worked on the Mercer coals here. The following sections of the Mercer are from along Mill Creek 3 miles north of Roseville:

Fred Schnepp's mine

	Ft.	in.
Shale	1	
Coal	2	2
Bony coal	0	3
Clay shale	0	9
Clay	3	6

Country bank

	Feet
Shale	3
Coal	2
Clay	3

The Mercer is also developed in the southwestern part of the quadrangle, along the gorge of Redbank Creek near the mouth of Little Sandy Creek. Three seams of coal are reported, two of them 18 inches thick, a third 8 inches thick.

Though it is obvious from the above that the Mercer coal as known has no other value than for local domestic use, it is important to mention that the Mercer horizon may carry valuable coal which is now deeply buried and which future exploration may prove and utilize.

CLAY AND SHALE

The clay and shale resources of the Brookville quadrangle consist of underclay found under all of the coal beds in the area, flint clay found in the Mercer horizon around Brookville, and shale which makes up a large percentage of the Allegheny strata throughout the quadrangle. Some of these are suitable for the manufacture of common, face, and fire brick, hollow tile, sewer pipe, and pottery.

Underclay

Underclays, often called fire clays, occur immediately under the coal beds of the Allegheny strata. Although the underclays are more refractory than most other clay and shale and are often quite suitable for the manufacture of fire brick, the term fire clay is usually restricted to flint clay or zones of very refractory underclay.

The chemical composition of underclays differs from other clays and shales. The oxides of iron, lime, magnesia, soda, and potash are the so-called fluxing components of clay because their presence in increasing amount makes clay melt at decreasingly lower temperatures. These fluxing components are present in the underclays to a smaller extent than most other clays and shale, and consequently the underclays are more refractory. Flint clay, however, contains even smaller quantities of these fluxing components and is much more refractory. The reason for the lesser percentage of fluxing components in underclays is a mooted question. The fluxing components may have been dissolved out by downward percolating waters containing humic acid or they may have been removed by plant roots incidental to plant growth at the time coal was forming.

The following analyses of underclays of the Brookville quadrangle are taken from Report H6 of the Second Pennsylvania Geological Survey and from Clay and Shale Resources of Pennsylvania, Bulletin M 23, of this series, by Henry Leighton. The last two analyses, although not of samples in the Brookville quadrangle, are of Jefferson County clays.

Analyses of plastic underclays from Jefferson County

No.	Ign.	SiO_2	Fe_2O_3	TiO_2	Al_2O_3	CaO	MgO	Na_2O K_2O	MnO	P_2O_5	SO_3
P2	9.72	58.12	3.33	.19	26.50	.07	.55	2.18	—	—	.05
P3	9.09	60.67	2.21	1.61	25.91	.08	.46	1.92	—	—	Tr.
P4	4.16	78.07	1.59	Tr.	14.44	.05	.48	1.67	—	—	Tr.
72	—	59.76	2.64	—	29.30	1.08	1.30	—	—	—	—
256	8.31	62.40	3.39	—	21.10	.97	.21	—	.10	.02	1.45
257	7.66	63.05	4.60	—	19.09	.64	.60	—	.01	—	2.42

The distribution of underclays is the same as the coals which they underlie. For this reason the crop lines of the Lower Kittanning and Upper Freeport coals on the Mineral Resources map serve also as a marker for the location of their underclays. Where the Mercer and Lower Clarion clays are commercially developed crop lines are properly shown on the map

Representative sections showing the thickness of all the underclays at many locations in the quadrangle have been presented in the chapter on Stratigraphy. For sections of the Middle Kittanning, Lower Freeport, and Upper Freeport clays the reader is referred to figures 8-10 which show the character of the Allegheny strata between the Upper Freeport and Lower Kittanning coals. For sections of the Lower Kittanning, Upper Clarion, Lower Clarion, and Brookville clays the reader is referred to figures 13-16 which show the character of the strata between the Lower Kittanning coal and the Brookville coal.

The average thickness of underclays in the Brookville quadrangle is presented here with the range of thickness that they show:

Underclay	Average thickness (feet)	Range of thickness (feet)
Upper Freeport	4–5	1 –15
Lower Freeport	2–3	1 – 6
Upper Kittanning	1–2	½– 3
Middle Kittanning	4–6	2 –12
Lower Kittanning	6–8	3 –20
Upper Clarion	2–3	1 – 4
Lower Clarion	6–8	2 –14
Brookville	1–4	½–10
Mercer	2–3	½–16

The Mercer, Lower Clarion, and Lower Kittanning clays are the only ones which have been or are being mined commercially in the quadrangle. An examination of the thicknesses in the above table explains this, with the added fact that these clays are of very good quality.

With the exception of the area between Little Sandy Creek and the southern border of the quadrangle the clays of the entire Brookville quadrangle fall within the so-called Brookville district of Jefferson County. In the vicinity of Sprankle Mills, in the southern area, Platt* speaks of a hard fire clay below the Brookville horizon. The Brookville horizon also appears along Little Sandy Creek in the vicinity of East Branch in Oliver Township and around Langville in Ringgold and Beaver Townships. Valuable flint clays have been found in the Mercer horizon at many places and it seems that the areas mentioned along Little Sandy Creek are worthy of further exploration. At the present none of the clay or shale of this southern area is being utilized. The Pittsburg & Shawmut Railroad could supply transportation for any industry established in this area.

The Brookville clay is no longer mined at any place in the quadrangle, but it was formerly worked at Old Humphrey quarry near Brookville where the clay is 6 feet thick. For a short time the 5-foot Brookville clay bed in New Humphrey quarry was worked. However, the Humphrey Brick and Tile Company is now working the 8-foot bed of Lower Clarion clay at the top of the quarry and is manufacturing face brick, hollow tile, and special tile products.

The following is taken from H. Leighton's report (Bulletin M23) and deals with the underclays of the Brookville district:

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* Platt, W. G.; Penna. Second Geol. Survey, Report H6, p. 55.

"South from Brookville between Fivemile Run on the east and Redbank Creek on the west is an area underlain by Allegheny strata. The Brookville coal has been mined at Conifer and the Middle and Lower Kittanning near Knoxdale. The Upper Freeport coal is mined at Ramsaytown and Knoxdale. Clays accompanying these coals are not developed. That good clays occur is shown by tests made on a sample from the roadside just south of Stanton. This clay about 3 feet thick is evidently a Freeport or a Kittanning clay. The sample (294) has good plasticity and a fair green strength. It fires to a cream to gray color and has a firing range from cone 06 to 01. It fuses at cone 20 to 26. It is best suited to the manufacture of buff face brick or sewer pipe. Probably the best clay in the area is the clay that underlies the Brookville coal. This has already been noted at the Humphrey plant at Brookville. In former years a pottery was operated by Newsome, Porter and Co. south from Brookville at the top of the hill above the railroad tunnel. This locality is described by Platt[1] and analyses are given of the Brookville clay used.

"At the pottery about 6 feet of the Brookville clay was used and it is stated that the material was somewhat sandy. It seems, however, that this horizon between the Clarion coal and extending down into the Pottsville sandstone is the most promising section for clays.

"At Summerville the Hanley Ceramics Co. has an exceptionally well equipped plant for the manufacture of buff face brick, frit-glaze brick, and other products. The plant is equipped with jaw crushers, Hanley dry pans, two Hanley auger machines, a Boyd press and 2-way tunnel kilns fired with gas. The clay used is mined about half a mile up a small stream north of the plant. Lower Kittanning clay is mined in mine No. 3. It consists of about 3½ feet of plastic clay underlain by 10 feet of harder inferior clay. Sample 291 represents the better portion. This has a fairly good plasticity and fair green strength. It burns cream to speckled gray with a burning range from cone 04 to cone 9, and fuses at cone 26. It seems suited to the manufacture of face brick, sewer pipe, or low-grade refractories. Lower Clarion clay is mined in mines Nos. 1 and 2. The average section shown is as follows:

Clay at Summerville

	Ft.	in.
Lower Clarion coal	2	2
Plastic clay	7	
Shales	18	
Brookville coal	3	
Clay	2	
Shales		

Clay at Sutton

	Ft.	in.
Upper Clarion coal	1	
Clay	3	
Brown shale	12	
Lower Clarion coal	2	6
Clay (no. 297)	7	

This clay has practically the same properties as the Lower Kittanning and the two are mixed in the plant. Samples 391 and 72 and 73 also represent the clays used at the Hanley plant. Their fusion points run from cone 20 to cone 28.

Three miles northwest of Summerville at Sutton, in Clarion County just west of the Jefferson County line, a cut along the New York Central Railroad shows a section of the Clarion beds.

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[1] Platt, W. G., Penna. Second Geol. Survey, Report H6, pp. 104-5.

This clay has good plasticity and fair green strength. It burns cream to gray with a firing range from cone 06 to 9 and fuses at cone 27. It seems suitable for the manufacture of fire brick, sewer pipe, or face brick.

At Corsica on the line between Clarion and Jefferson Counties the DeHaven Coal Co. mines the Lower Kittanning coal by the stripping method. Above the coal is from 10 to 15 feet of brown shale (no. 295) which is removed. This shale has fairly good plasticity and a fair green strength. It burns to a red to brown color with a burning range from cone 08 to cone 04. It is suitable for face brick manufacture. Below the coal lies a bed of plastic clay. The upper portion, which was sampled as no. 296, is light gray and free from siliceous material. It is from 2 to 3½ feet thick. The lower portion is more siliceous and is about 3 feet thick. The good clay has fair plasticity and green strength. It fires to light to dark gray with a firing range from cone 06 to 13, and fuses at cone 32. It is evidently an excellent fire clay and could be used for refractories. This property has a rail spur into it and it would seem that the shale and clay could be developed easily, or that other similar deposits could be opened in the western part of the county. North from the Brookville-Corsica road the Allegheny group forms the surface rock for 4 or 5 miles, beyond which the lower Pottsville beds become the dominant stratum of the northern townships. Little is known about the clays northeast of Brookville, though the horizon of the Brookville-Mercer clays may be expected. Brown shales of good quality occur between Brookville and Sigel and clay blossoms were noted near here.''

Flint Clay

Flint clay is a name applied to a special kind of clay which is commonly associated with coal strata. It is very hard and blocky, exhibits a conchoidal fracture with very sharp edges, and usually has a light or medium gray color which is sometimes bluish. It closely resembles many limestones and is hard enough so that it rings from the blow of a hammer. Unlike most clays it does not weather to a mud but retains its flint-like character until reduced to powder. Another variety of flint clay is the so-called nodular or burly clay. The only difference is the nature of fracturing, the nodular clay breaking along irregular surfaces covered with small round protuberances or nodules. The quality of both clays is good. See plate 15.

When flint clay is ground up and molded it is necessary to add small amounts of plastic clay, for the flint clay will not bond into brick by itself. The proportion of plastic clay which is added varies according to the proposed use of the brick or tile. Very little plastic clay is added if a high refractory product is desired, for the addition of plastic clay lessens the refractory property. However, plastic clay is added in fairly large amounts if the product is supposed to be very tough.

The following average analysis of several Pennsylvania flint clays (not from the Brookville quadrangle) serves to show the great difference between flint clay and plastic underclays:

	Per-cent		Per-cent
Silica	44	Magnesia	.2
Alumina	38	Alkalies	.4
Protoxide of iron	1.2	Water	14
Titanic acid	1.5		
Lime	.3		99.6

There is considerably more alumina and a great deal less of the fluxing components in flint clay than in the plastic underclays.

Although no flint clay is commercially mined in the Brookville quadrangle it definitely occurs in the district. At the New Humphrey quarry one mile southeast of Brookville the measured section showed 26 inches of flinty clay near the bottom of the quarry and below a section containing an unusual amount of plastic clay. A drill hole nearby showed 43 inches of flint clay. The flint clay is presumably in the Mercer horizon. The section follows:

Drill hole at New Humphrey quarry

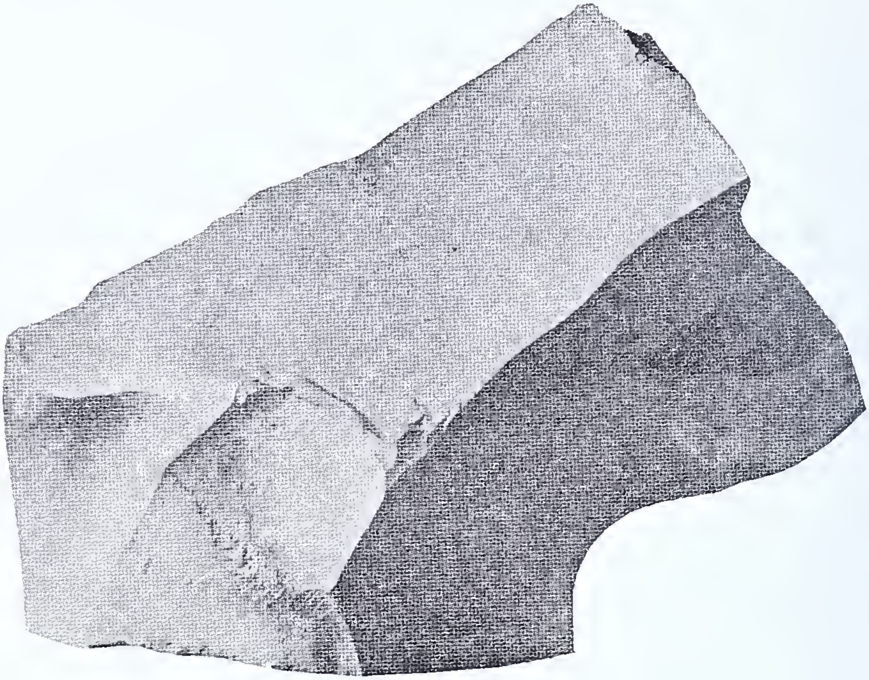
	Ft.	in.		Ft.	in.
Clay	2		Coal		6
Coal	2	6	Clay	1	9
Soft clay	1	6	Dark clay	2	4
Coal		10	Dark shale		4
Clay	13		Dark clay		5
Coal	1		Sandstone	7	10
Slate		10	Flint clay	3	7
Coal	2	1	Sandstone	1	5
Clay	1	7			

Leighton has this to say about the flint clay at New Humphrey quarry and other localities in the quadrangle:

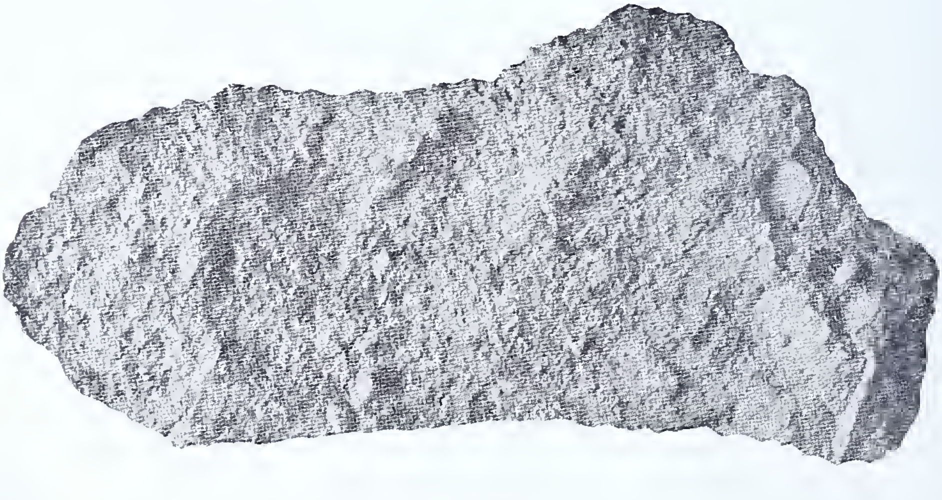
"Similar flint clay crops out on an adjoining part of the property of the company along the road just east of the plant, and sample 290 represents surface samples of it. This clay fired to a cream color with a firing range from cone 06 to cone 13 and fused at cone 32½. It is a good grade of flint clay suitable for the manufacture of refractories. Sample 289, the clay from the quarry, has good plasticity and a fair green strength. It burns salmon to brownish-gray with a firing range from cone 06 to cone 01. It fuses at cone 17. It is not a fire clay but is suited to the manufacture of face brick. The company now uses mostly the upper shale but this clay could be mixed with the shale for different effects. The plant is equipped with rolls and dry pans and two Bonnat auger machines. The brick and tile are burned with a battery of 17 round, gas-fired kilns.

"Samples 393 and 394 represent flint clay taken from the O'Neil mine on Swamp Run, just south of Brookville. These are from the Mercer horizon. Sample 393 fired to a white to cream color and sample 394 to a gray. No. 393 fused at cone 29 and no. 394 at cone 33. Both have a firing range from cone 3 to cone 13. They are flint clays of good grade and are suited to the manufacture of various refractories. F. B. Hetrick, owner of the property, states that the clay lies 12 feet below the Brookville coal and ranges from 4 to 11 feet thick. The clay is trucked to the railroad and shipped to various points. Following is the section:

PLATE 15



A. Block flint clay from Clearfield County.



B. Nodular flint clay.

	Ft.	in.
Coal		4
Clay	1	
Sandstone	10	
Semi-flint clay	1+	
Dark flint clay		2 to 1 foot
Light flint clay	3 to 6 feet	
Sandstone	2+	

"The flint clays in the area just east of Brookville indicate that there is a bed or beds of flint clay between the Brookville coal and the Connoquenessing sandstone in the area which will bear further study or prospecting. Similar flint clays are known both east and west of Reynoldsville and it seems likely that there is an area of such clays in the intervening district."

Shale

Shale is widely used for making clay products which do not require refractory properties, such as building and paving brick, tile, and terra cotta.

The shale above the Lower Kittanning coal at Corsica has already been mentioned as being suitable for face brick manufacture. Though tests have not been made on other similar shales of the Allegheny group, it seems plausible that many shale horizons of the group throughout the quadrangle would be suited to this purpose. In the event of increased activity in the brick industry, it would be advisable to test some of the shales which are so abundant near the town of Brookville.

Following are the physical tests which have been made on clay and shale specimens from the Brookville quadrangle:

Physical tests of clays

Sample number	Percent water of plasticity	Percent linear drying shrinkage	Time of slaking, minutes	Modulus of rupture pounds per sq. in.	Maximum linear burning shrinkage	Maximum shrinkage at cone	Fusion point cone	Best burning range cones	Firing color	Suggested uses
72	22.56	9.35*	5		24.10*	9	20½			Building brick or tile
73	24.66	13.57*	9		26.57*	9	27½			Fire brick
289	21.7	4.2	6	153	5.90	02	17	07–02	Salmon to gray	Face brick
290	18.9	4.2	5	—	6.90	05	32½	07–11	Cream	Fire brick
291	19.9	5.3	7	118	3.60	9	26	05–6	Cream to gray	Face brick, sewer pipe
294	23.8	4.0	7.5	180	6.60	4	26	07–02	Cream to gray	Face brick, sewer pipe
295	22.5	3.6	4	175	6.10	02	14	010–05	Red to brown	Face brick
296	20.0	3.9	3	110	4.60	02	32	07–11	Light to dark gray	Fire brick
297	21.8	5.3	7	125	3.80	1	27	07–6	Cream to dark gray	Fire brick, face brick, sewer pipe
391	23.1	4.7	7	129	5.8	11	28	1–11	White to gray	Face brick, fire brick
393	21.6	4.0		35	5.9	11	29	1–11	White to cream	Refractories
394	20.7	1.5			5.9	9	33	1–11	Gray	Refractories

* Volume shrinkage.

Localities from which clays were obtained:

72. Plastic clay, Clarion bed, lower part, Hanley Ceramics Co., Summerville.
73. Plastic clay, Clarion bed, upper part, Hanley Ceramics Co., Summerville.
    Nos. 72 and 73 above, were tested by Shaw and described in Bull. M-10, 1928.
289. Plastic clay, Clarion (?) bed, Humphrey Brick & Tile Co., Port Barnett.
290. Flint clay, Mercer bed, Humphrey Brick & Tile Co., Port Barnett.
291. Plastic clay, Lower Kittanning bed, Hanley Ceramics Co., Summerville.
294. Plastic clay, on road near Stanton.
295. Shale, over Lower Kittanning coal, DeHaven Coal Co., Corsica.
296. Plastic clay, under Lower Kittanning Coal, DeHaven Coal Co., Corsica.
297. Plastic clay, Lower Clarion bed on N. Y. Central Railroad, Sutton.
391. Plastic clay, Lower Kittanning bed, Hanley Ceramics Co., Summerville.

393-394. Flint clay, Mercer bed, O'Neil mine, Swamp Run, 2 miles southeast of Brookville.

NATURAL GAS

By M. N. Shaffner

Origin and Accumulation

Several theories have been advanced for the origin of natural gas A full discussion of them does not necessarily come within the scope of this report. The one most commonly accepted today assigns an organic origin, that it was formed from the remains of plants and lesser amounts of animal matter which were deposited along with sediments in bodies of fresh or salt water many millions of years ago. Before burial the organic matter was partially decayed and deoxodized, changing the original material to oily, waxy, resinous matter. After burial by thousands of feet of subsequent sediments, the organic matter was squeezed and heated by the pressure of the overlying sediments and by crustal movements until it was transformed into carbonaceous products such as coal, petroleum, and natural gas. The difference in character of these resultant products having a common origin is due to the manner in which they were originally deposited and to the differences in pressure and heating to which they had been subjected. For a full discussion of the formation of petroleum and natural gas see Clarke's Data of Geochemistry.[1]

If the tiny globules of oil and bubbles of gas remained disseminated throughout the shale where they were originally formed from carbonaceous material, present methods of recovery of oil and gas would be impossible. Accumulation into commercial pools is accomplished by migration of the oil and gas with water from the point of origin to a porous stratum such as sandstone. The chief factors influencing this movement are: The pressure due to the weight of additional sediments, the rocks above being less compacted than those below, and the strong capillary attraction of water. Further segregation of oil, gas, and water is, however, essential to productive accumulation. In flat-lying or only slightly tilted beds the oil and gas would be forced slowly along by the water and there would be little concentration. In dipping beds, water, oil, and gas continue to migrate up the dip until they are arrested either by a change in dip, discontinuance of bed, or other possibilities. During migration the water, oil, and gas begin to separate according to their specific gravities; and after having been arrested in a trapped structure, the separation becomes complete, with gas on top exerting pressure in all directions; the oil beneath it being buoyed up by the water at the bottom. Where oil and gas pools have been formed it has been found that there are always anticlinal domes or some type of closed structure in which the oil and gas have been trapped or halted in their progress and there concentrated.

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[1] Clarke, F. W., The data of geochemistry: U. S. Geol. Survey Bull. 770, pp. 744-756, 1924 and earlier editions.

The theoretical conditions for accumulation of oil and gas as outlined above are ideal, but other factors are instrumental in determining the location of a pool, such as a change in porosity of the "sand" from place to place, or a slight change in dip.

Composition and Uses

Natural gas is composed chiefly of a mixture of gaseous hydrocarbons, methane, ethane, and propane with small amounts of carbon dioxide, nitrogen, and hydrogen sulphide, and in some cases a trace of helium and other rare gases. Methane is nearly always the predominating constituent, representing about 80 percent by volume, while ethane is second with 10 to 20 percent.

Natural gas is classified as either wet or dry, according to its content of gasoline. Wet gas is commonly associated with oil in oil fields and is generally obtained from the same sand that yields the oil. Dry gas contains chiefly methane and is not often associated with oil-producing sands. No analyses of natural gas from wells within the Brookville quadrangle or within Jefferson County are available. The following analyses are of gas from wells in counties adjacent to Jefferson County:

Anaylses of Natural Gas

County	Sand	Date	B.t.u.	Sp. gr. Air = 1	Chemical composition in percent						
					H_2	N_2	CO_2	O_2	Total paraffin	CH_4	C_2H_6
Armstrong	Fourth	1911	1184	.64		1.5			98.5	81.6	16.9
Clarion	Fourth	1911	1703	.57		1.1			98.9	96.4	2.5
Clarion	Bradford	1911	1189	.65		1.7			98.3	80.5	17.8
Clarion		1931	1135	.64		.1	.1	.1	99.7	82.9	16.8
Elk		1916	1146	.61		.8			99.2	88.0	11.2
Forest	Third	1911	1279	.70		1.0			99.0	70.8	28.2
Indiana		1884			22.5	.8	2.3	7.3	67.1	60.3	6.8

Natural gas is odorless, tasteless, colorless, and non-poisonous. When burned with a sufficient amount of air it forms a transparent, blue flame. Its high heat content and high flame temperature make it an excellent fuel. It needs no preparatory treatment and is easily transported. Natural gas is used chiefly as a fuel for domestic and industrial purposes. When used with the proper appliances it gives excellent illumination. Although electricity has to a great extent displaced it for lighting purposes, gas is still used for illumination in the rural districts where electricity is not available.

Oil is not known to occur in commercial quantities in the Brookville quadrangle. Some oil has been reported from the Murraysville and Hundred-foot sands, but the quantity probably is not large, and in most cases it was reported only as a "show."

Gas Sands

The production of natural gas in the Brookville quadrangle comes entirely from sandstone, called "sand" by the drillers. The records of the wells are generally incomplete and inaccurate, and until an accurate correlation of the gas sands is made by microscopic examination of well cuttings, only a tentative correlation can be made by a study of what appear to be the best well records. The stratigraphic relationship of the subsurface rocks was discussed earlier in this report under the chapter on Stratigraphy and need not be repeated here.

Approximately 500 records of wells drilled in the quadrangle were plotted and studied. The most striking features of most of the sands are: Their lenticular nature, wide range in distance with respect to a definite marker, variation in thickness and frequent splitting of the beds. In view of those characteristics which the majority of the sands show, it would, perhaps, seem more logical to consider them not as definite sandstone units, but rather as sandy intervals, occurring within certain limits.

The drillers' interpretation and naming of the sands is not only generally inaccurate, but also inconsistent; for example; they frequently call the sand immediately below the Tiona, the Bradford, which according to the generally accepted sequence of sands is the First Balltown. Also, they have called the Kane sands the Elk, and vice versa. One of their inconsistencies lies in the fact that the name Bradford is also applied to sands occurring at other positions in the section. A few sands are, however, usually logged correctly. This is particularly true of the Speechley, probably because it appears to be the most persistent and to vary relatively little in depth from the top of the Red Rock. Therefore, the following correlation and naming of the sands is based only in a small part on the interpretation of the drillers, and mainly by a comparison with the position of the sands in other regions of western Pennsylvania as interpreted by geologists.

Rather than showing composite sections representative of various parts of the quadrangle, as is customarily done in most reports, the diagram, plate 16, was constructed from selected individual well records running in a northwest-southeast direction across the quadrangle. By this method it was hoped to illustrate better the variation in thickness and lenticular nature of the sands and also show their range from a definite horizon. The reference datum of the diagram and the ensuing discussion of the sands was based on the top of the Red Rock because it is easily recognized and is, therefore, the main marker for the drillers in this region. A surface reference on the Vanport limestone may be obtained for nearly all points in the

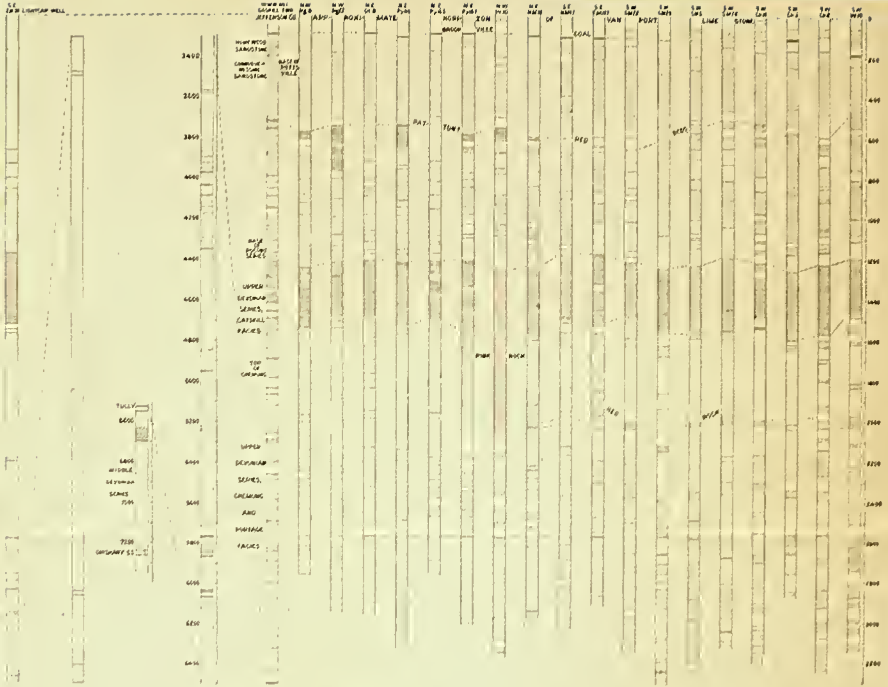

PLATE 5. SECTIONS FROM GAS WELL RECORDS SHOWING THE NATURE OF THE SUBSURFACE STRATA.

quadrangle by comparing the surface structure map (plate III) with the subsurface map (plate IV) contoured on the Vanport limestone and the top of the Red Rock respectively.

Description of Sands

Big Injun sand. The Big Injun, which is sometimes called the Mountain sand, was recorded as being white, gray, and green. It is not known to contain commercial quantities of gas in the Brookville quadrangle, but water is frequently encountered in it which must be cased off. The top ranges from 830 to 1,000 feet, and has a regional average of 920 feet above the top of the Red Rock. In logging the Big Injun, the drillers commonly include other sands with it, and excessive thicknesses up to 300 feet have been recorded. Normally, it ranges from 80 to about 200 feet, and averages about 150 feet in thickness. The Big Injun in some regions is an excellent marker, but in this area it is too variable for that purpose.

Squaw sand. The Squaw sand lies immediately below the Big Injun and frequently has been logged with that sand. The interval from the top of the Squaw to the top of the Red Rock averages 680 feet for the quadrangle. Its thickness ranges from 20 to about 100 feet. This sand is generally dry and only ''show'' gas has been reported; the occurrence of water is common. Some records indicate the Squaw sand separating red beds, which may be the Patton shale.

First Gas, Second Gas, and Salt sands. Following the Squaw come three sands which, in descending order, have been designated by the drillers as the First Gas, Second Gas, and Salt sands. These sands occur at average intervals of 580, 520 and 455 feet respectively, above the top of the Red Rock, and their thicknesses average 40, 45, and 40 feet respectively. The First Gas and the Second Gas possibly represent a split of the Second Gas sand of Armstrong and Clarion Counties, and the Salt sand may be the equivalent of the Berea of those regions. The First Gas and Second Gas are not known to be productive in the Brookville quadrangle. Some gas has been reported in the Salt sand, but it generally contains salt water.

Murraysville sand. The Murraysville, which is described as a gray and rarely as a black sand, is usually correctly named by the drillers, although they have sometimes called it the First Clarion. This is, stratigraphically, the highest sand producing commercial quantities of gas in the Brookville quadrangle. The production, however, is generally small, and many of the wells producing from this sand have been reported to ''blow down'' soon. The Murraysville sand derived its name from Murraysville in Westmoreland County where it had produced large quantities of gas. The top of this sand ranges from 310 to 390 feet, and averages 345 feet above the top of the Red Rock. Its thickness ranges locally from 10 to 90 feet, but it has a rather general uniform thickness of 45 feet.

Hundred-foot sand. The Hundred-foot sand derived its name from the fact that, in some regions of western Pennsylvania, it maintains a persistent thickness of 100 feet. In this area it is quite persistent in occurrence, and locally attains a thickness of 100 feet, but its average thickness of 40 feet is rather general throughout the quadrangle. Its position above the top of the Red Rock averages about 250 feet, and ranges from 220 to 290 feet. Although the Hundred-foot is not one of the important producers in the quadrangle, considerable quantities of gas were reported to have been found in that sand at a few places. On most of the well records the drillers have correctly identified this sand as the Hundred-foot, but on some it was designated the Second Clarion. Also, where the Hundred-foot is split, the upper part was called the Red Valley and the lower part the Second sand. The color of this sand was rarely indicated, but white has been reported.

Thirty-foot sand. The Thirty-foot, which is frequently called the Third Clarion, is commonly logged as white and rarely as a red sand. This sand is fairly persistent in occurrence, and its position above the top of the Red Rock averages 140 feet, but ranges rather widely. A maximum thickness of 100 feet was recorded in Knox Township, but the general range is from 5 to 75 feet, and the average is 25 feet. Although the Thirty-foot appears to be less productive than the Murraysville and the Hundred-foot, a few fairly large wells have been reported producing from this sand.

Snee sand. The Snee sand is commonly reported as being white and occasionally as red. The equivalent of this sand in other regions is known as Blue Monday, Boulder, and Hickory. The Snee apparently is not very persistent in the Brookville quadrangle. It occurs below the Thirty-foot, and from directly on top of, to 90 feet above the top of the Red Rock. The thickness ranges from 5 to 50 feet, and averages 20 feet. Gas has been reported from it in a few wells scattered over the quadrangle.

Gordon and Bayard sands. From just below the top of, and down to about 255 feet in the Red Rock, four sporadic sands have been recorded, which correspond generally to the Gordon Stray, Gordon, Bayard Stray, and Bayard of other regions. These sands have relatively little importance in this area, but an occasional well has found gas in them. The Gordon Stray is, apparently, the least persistent of the group; where present, it lies from 10 to 40 feet below the top of the Red Rock, and has an average thickness of 15 feet. This sand was encountered more often in the wells in Eldred Township, and was reported to have produced some gas. The Gordon is sometimes logged as the "packer sand." Its average depth below the top of the Red Rock is 105 feet, and it also averages 15 feet thick. This sand is fairly persistent in Eldred and Warsaw Townships where it has produced some gas. The Bayard Stray has been found more often in the northern part of the quadrangle, and has been productive at some places. The Bayard lies at an average depth of 255 feet below the top of the Red Rock, and has an average thickness of 20 feet. It is the most persistent sand of this group in the quadrangle and occurs quite constantly in Redbank Township where it is occasionally productive.

Elizabeth sand. The Elizabeth is a fairly persistent sand which appears to occupy a somewhat definite position from 285 to 330 feet below the top of the Red Rock. The thickness is about 25 feet. This sand has been reported to be productive in Eldred, Rose, Knox and Beaver Townships. It is known locally as the Deemer sand.

Warren sands. In the interval from below the Elizabeth down to approximately 935 feet below the top of the Red Rock, five sands have been logged which are relatively unimportant and exceedingly erratic in occurrence. These sands have been correlated with the First Warren, Second Warren, Third Warren, Fourth Warren and Fifth Warren sands of other regions. Their respective average depths below the top of the Red Rock are 415, 535, 725, 860 and 935 feet; and their respective average thicknesses are 25, 35, 30, 35, and 40 feet. These sands are generally non-producers of gas in the Brookville quadrangle, but the First Warren has yielded considerable quantities of gas in Pine Creek Township, and large wells were encountered in the Third Warren in Oliver Township.

Speechley Stray. The Speechley Stray was logged as a hard, gray sand. Its position below the top of the Red Rock ranges from 985 to 1,050 feet, and averages 1,020 feet. The thickness varies little from the average of 20 feet. This sand is lacking throughout most of the quadrangle, but present in parts of Mill Creek, Clarion, Limestone, Clover, Warsaw, Pine Creek, Rose, and Ringgold Townships. It is commonly barren but some gas was reported to have been obtained from it in Mill Creek, Warsaw, and Pine Creek Townships.

Speechley. The Speechley is definitely the most persistent and generally the most prolific sand in the Brookville quadrangle. Although its position may vary locally, it is remarkably constant in depth at an average of 1,075 feet below the top of the Red Rock. Also, it maintains a fairly uniform thickness which varies little from 30 feet. The drillers have sometimes confused the Speechley with the Speechley Stray, but on the whole they have identified it correctly, and reported it as gray, chocolate, open-grained, and hard. The Speechley is very persistent and productive in Eldred, Warsaw, and Union Townships, and although persistent in occurrence in Rose and Knox Townships, it is less productive. In some localities, and particularly in Pine Creek Township, the Speechley is immediately underlain by a thin sand which is probably a split of the Speechley and has been logged as the Second Speechley. Some gas was reported in it.

Tiona sand. Immediately below the Speechley is the Tiona, and it has been logged as such by the majority of the drillers, although on some records it was called the Big Gray. This sand occurs at an average depth of 1,150 feet, and ranges from 1,100 to 1,190 feet below the top of the Red Rock. The thickness ranges from 10 to 80 feet and averages 35 feet. The Tiona is generally present and productive in nearly all parts of the area. Considerable quantities of gas are reported to have been obtained from this sand in parts of Knox Township.

First Balltown sand. The First Balltown is an erratic sand lying from 1,220 to 1,310 feet, and averaging 1,280 feet below the top of the Red Rock. It is from 10 to 80 feet thick with an average of 35 feet. Some gas has been produced from the Tiona in various parts of the quadrangle, and sizable production was reported from it in Pine Creek and Knox Townships.

Second Balltown. The Second Balltown is also an erratic sand, and occurs directly below the First Balltown. It is, however, persistent in some localities, such as parts of Eldred, Warsaw, Pine Creek, Clover, and Oliver Townships. Important production was reported to have been found in this sand in Eldred, Pine Creek and Oliver Townships. The Second Balltown lies from 1,300 to 1,380 feet below the top of the Red Rock; the average depth is 1,350 feet. The average thickness is 30 feet; the minimum is 10 and maximum 80 feet.

Sheffield sand. This sand has a rather regular occurrence in the quadrangle, lies at an average depth of 1,410 feet, and ranges from 1,360 to 1,450 feet below the top of the Red Rock. It is up to 100 feet thick locally, but has a somewhat constant regional thickness of 30 feet. Gas has been obtained from the Sheffield sand in nearly all parts of the area, and was reported as particularly abundant in Eldred, Union, Clarion, Limestone, and Oliver Townships.

First Bradford sand. The First Bradford is frequently designated as the Kanesholm sand. It is not persistent, nor is it very productive in the Brookville quadrangle. The depth to this sand from the top of the Red Rock ranges from 1,460 to 1,525 feet and averages 1,480 feet. The thickness averages 25 feet, and ranges from 5 to 70 feet.

Second Bradford sand. The Second Bradford is commonly called the Cooper sand in this area. It is similar to the First Bradford with respect to persistence and production. Its depth below the top of the Red Rock averages 1,585 feet; the minimum is 1,540 and the maximum 1,605 feet. It has a range in thickness from 10 to 55 feet; the average is 30 feet.

Third Bradford sand. In the Brookville quadrangle the Third Bradford is the most important sand found below the Speechley. In fact it ranks next to the Speechley in persistence and production. It was logged as gray and chocolate, and the occurrence of salt water was noted on a few records. The depth of this sand below the top of the Red Rock is relatively constant at 1,665 feet; the minimum depth is 1,610 and the maximum is 1,670 feet. The thickness is fairly uniform at 25 feet, but ranges from 10 to 65 feet.

Kane sands. Below the Third Bradford there are three sands which have been correlated with the First Kane, Second Kane, and Third Kane of other regions. Their respective average depths below the top of the Red Rock are 1,760, 1,845 and 1,925 feet. All of these sands have a variable thickness which ranges from 5 to about 60 feet, and averages about 20 feet. The First Kane is more persistent and productive in parts of Eldred, Warsaw, Rose, Knox, and Oliver Townships. The Second Kane and Third Kane sands are generally present and productive in Rose Township.

Elk sands. Below the Kane group come three sands which appear to correspond to the First Elk, Second Elk, and Third Elk sands of other regions. Their average positions below the top of the Red Rock are 2,005, 2,085, and 2,180 respectively. All have an average thickness of about 25 feet. Not very many of the wells in the quadrangle were drilled through these sands; therefore, little is known about their areal distribution. Gas was reported to have been found in these sands at various places in the quadrangle.

Two wells near Brookville have penetrated the strata below the Third Elk, and sands were logged at 2,290, 2,335, 2,400, 2,500, 2,700 and 2,890 feet below the top of the Red Rock.

Production and Use

The Brookville quadrangle ranks as one of the major gas-producing areas in western Pennsylvania. The field has passed its prime but successful wells continue to be drilled, and many of the early wells are still producing. Up to and including 1933, over 1,200 wells had been drilled within the limits of the quadrangle; approximately 65 percent are still producing, 25 percent were abandoned, and 10 percent were completed dry. The first well known to be drilled in this area was completed in 1884 in the Borough of Brookville. This well reached a depth of 1,950 feet, and some gas was reported. The deepest well known was drilled by Humphrey Brick and Tile Company in 1925, near the eastern boundary of the quadrangle in Pine Creek Township, due east of Brookville. It reached a depth of 4,145 feet below the surface, or about 3,000 feet below the top of the Red Rock. Gas was reported in the Hundred-foot, Thirty-foot, Third Bradford, and Second Elk sands, but none below.

Production figures are so incomplete and inaccurate that it is impossible to make even an approximate estimate of the quantities of gas produced in the quadrangle, but the production doubtless has been large. Initial rock pressures and volumes were indicated on relatively few records, but some general idea of the character of the wells was obtained. Although it was reported that some wells came in with initial productions in excess of 20,000,000 cubic feet, the largest volume of gas indicated on any of the records is 13,385,736 cubic feet, which was encountered in a well in Rose Township on the

Galbraith farm just east of Brookville. This well was drilled to the Second Kane but the producing sand was not indicated. Wells with initial volumes of over one million cubic feet are unusual, and the average initial production per well for the area is between 250 and 500 thousand cubic feet. Initial rock pressure up to a little over 1,000 pounds per square inch has been reported, and the average is near 600 pounds per square inch.

The greater part of the consumption of natural gas in the quadrangle is for domestic purposes, but some gas is also used industrially, particularly by Hanley Ceramics Company at Summerville and Humphrey Brick and Tile Company at Brookville. The supply of natural gas in the quadrangle exceeds the demand and a considerable quantity is piped to industrial centers to the west, where much of it is used in the manufacture of iron, steel, and glass.

The gas companies operating in the quadrangle are: United Natural Gas Co., T. W. Phillips Gas and Oil Co., Hanley and Bird Gas Co., Humphrey Brick and Tile Co., F. C. Deemer Gas Co., Manufacturers Light and Heat Co., Jefferson-Elk Gas Co., Jefferson County Gas Co., Acme Drilling Co., Howe Gas Co., and Redbank Gas Corp.

Gas Pools

The gas pools in the Brookville quadrangle trend in a general northeast-southwest direction, and are very irregular in outline. There are two major pools, seven minor pools, and fourteen small outlying pools, which occupy a total area of approximately 96 square miles of the quadrangle. The producing sands were indicated on only about 50 percent of the records. Therefore, the relative importance of the producing sands in the pools and various parts of the pools as described below, may only be approximately correct.

The largest pool in the quadrangle lies generally south and east of Brookville, and occupies an area of about 38.5 square miles. In the area east of Brookville and north of Sandy Lick Creek, most of the gas is produced from the First Balltown, Second Balltown, and Third Bradford sands. In the area south of Sandy Lick Creek to just north of Knoxdale, and westward to Smathers Run, the chief producing sand is the Third Bradford, but most of the gas comes from the Murraysville, Hundred-foot, Speechley, Tiona, First Balltown and First Kane. West of Ramsaytown and north of Conifer, the First Balltown, Sheffield, Second Bradford, Third Bradford, First Kane and Second Kane supply most of the gas.

The next largest gas pool lies north and west of Brookville. It extends across the quadrangle in an irregular band which occupies about 28.5 square miles. In southern Clarion and Union Townships, and northern Limestone and Clover Townships, the Speechley is the most important sand, but the Murraysville, Sheffield, and Third Bradford sands are also very productive. The Speechley and Third Bradford sands are equally important in southeastern Eldred and northern Rose Townships, and produce practically all of the gas. In southwestern Warsaw and northwestern Pine Creek Townships, the Speechley is somewhat more productive than the Third Bradford, but they are still the leading producers, although considerable quantities of gas also come from the Murraysville, Hundred-foot, First Kane, and Second Kane sands.

The gas pool north of Mill Creek in the northwestern part of the quadrangle occupies an area of approximately 3.5 square miles. The production is mainly from the Speechley sand.

The isolated pool south of Mill Creek in the northwestern part of the quadrangle has an area of about 1.7 square miles, and is essentially a Speechley pool.

The pool in the northeastern part of the quadrangle has an areal extent of about 5.85 square miles, and is connected with the large pool to the south by a narrow neck at Richardsville. The Speechley also produces most of the gas in this pool.

Southwest from Brookville, along and near Redbank Creek, occur 12 small outlying gas pools. Only a relatively few records for the wells in these pools were obtainable, and most of them do not show the producing sands. Their areas in squares miles, and the known producing sands for these pools are: West of Coder 0.17; west of Baxter 0.18; southwest of Harlan 0.2; south of Summerville 0.72, Tiona; north of Shannondale 0.72, Speechley and First Kane; east of Shannondale .06, First Kane; south of Shannondale 0.17, Bayard Stray; north of Langville .03, Elizabeth, Speechley and Tiona; west of Langville .04, Second Balltown; northwest of North Freedom 0.8, Speechley and Tiona; west of North Freedom .13, Hundred-foot, Speechley, Tiona, and First Balltown; and south of North Freedom .19.

South of Conifer and north of Worthville a pool having an area of about 3 square miles, and trending in a northwest-southeast direction, is detached from the largest pool in the quadrangle by a narrow barren strip. The sands known to be producing most of the gas are Second Balltown, Sheffield, Third Bradford, First Kane, Second Kane, and First Elk.

The small outlying pool southeast of Worthville has an area of .08 square mile. Some of the gas comes from the Thirty-foot and Sheffield sands.

The irregular gas pool in the southern part of the quadrangle which includes the towns of Cool Spring and Sprankle Mills has an area of 6.65 square miles. In the area from just north of Cool Spring to Sprankle Mills and eastward to just beyond the Pittsburg and Shawmut Railroad, the Speechley is the most important producer, but the greater amount of gas is produced by the Murraysville, Hundred-foot, Third Warren, First Balltown, Second Balltown, and Third Bradford and First Kane sands. South of Cool Spring and just north of Laurel Ridge School, wells producing from the Third Warren sand on the Means and Harriger farms had respective initial productions of 1,000,000 and 3,000,000 cubic feet of gas. On the Aber farm southeast of the above location, a well had an initial production of over 1,000,000 cubic feet in the Second Balltown sand. South of East Branch on the Hadden and Straitiff farms, wells producing from the

First Kane sand had respective initial productions of 1,107,000, and 1,565,000 cubic feet. In the area westward from Sprankle Mills to near Cherry Run, little is known about the producing sands.

The pool in the southeast corner of the quadrangle produces most of its gas from the Hundred-foot, Speechley, Third Bradford, and First Kane sands. The area included by this pool is about 2.9 square miles.

Production in the pool northeast of East Branch and east of Indiancamp Run comes mainly from the Speechley, First Balltown, and Third Bradford. The pool comprises an area of about 3.02 square miles.

The sands producing gas in a very small pool northeast of Knoxdale could not be determined.

Relation of the gas pools to the structure

The relation of structure to the accumulation of oil and gas was first recognized in 1883 by I. C. White, former State Geologist of West Virginia, whose anticlinal theory explained the northeast-southwest trend of the oil and gas pools known at that time and which has since been a practical theory to use in the location of other pools.

On Plate IV it will be noted that there is a general relationship between the gas pools and the structural highs, or that the main areas producing gas lie on or near the anticlinal axes; whereas the nonproductive areas are more closely associated with the structural lows or synclines.

Although the major part of the largest pool in the quadrangle lies northwest of the axis of the North Freedom anticline, it does, however, follow the northeast-southwest trend of the axis, and appears to be confined on the north by the axis of the Fairmount syncline and on the south by the axis of the Worthville syncline. Also, the barren strip south of Conifer, which appears to have detached a part of the southwestern end of the main pool is structurally low, and has caused the axis of the anticline to be offset to the north. The small isolated pools occurring on and near the pronounced dome on the North Freedom anticline should not necessarily condemn the remainder of the area since it appears that it has not been thoroughly tested, and it also appears that most of the wells have not explored the deeper sands.

The next largest pool in the quadrangle, which occurs north and west of Brookville, is likewise generally associated with structural highs, as are also those pools to the north; and in the southeastern part of the quadrangle, gas production occurs generally on and near the Sprankle Mills anticline.

Numerous dry holes were, however, drilled in the main productive areas, and, conversely, gas has been found in less favorable territory, or in the synclines, such as the small pools southwest of Brookville along the Fairmount syncline. The failure of wells to produce gas in favorable areas may, in part, be due to unobserved reverse structures, but mostly to the lack of porosity of the sand, and the productive wells found in the synclines may be due to local favorable structures which had not been detected.

SANDSTONE

Sandstone was not quarried or used commercially in the Brookville quadrangle in 1940. The Connoquenessing and Homewood sandstones of the Pottsville series could be so used.

Many years ago the Carr quarry was operated on Tunnel Hill in South Brookville in the 20-foot thick massive, brown, Homewood sandstone. The Homewood sandstone is typically massive, often cross-bedded, coarse-grained, gray to tan and brown in color, and averages 40 feet thick. Much of it is suitable for fine building stone. It is resistent to weathering when tightly cemented, but in places it is loosely cemented, as near Sprankle Mills, and this rock would not be very durable. Perhaps the best Homewood sandstone in the quadrangle is near Brookville and along the brow of the valleys of North Fork and its tributaries. This area would be suggested for any proposed quarrying. Being near Brookville, transportation facilities are available. The horizon of the Homewood is often marked by massive sandstone boulders which occasionally form rock cities. The horizon occurs at the top of the valley of Mill Creek in the northwestern part of the quadrangle, Redbank and Little Sandy Creeks in the southwestern part, and around East Branch in the southeastern part.

The Connoquenessing sandstone is a massive, fine- to medium-grained, white or light gray rock which has an exposed thickness of 90 feet in the immediate vicinity of Brookville. Where it was observed cropping out deep in the valleys of Sandy Lick and Redbank Creeks within a mile of Brookville, it appeared to be suitable for good building stone or for ballast and lighter road metal. The horizon of the Connoquenessing sandstone also lies deep in the valleys of Redbank Creek in the southwestern part of the quadrangle and North Fork in the northeastern part of the quadrangle, though in both these places it is largely concealed by thick talus along the steep valley walls. For this reason the vicinity of Brookville seems to offer the only location of possible commercial utilization.

In the Worthville syncline, from Worthville to Knoxdale and Ramsaytown, the basal Conemaugh carries the Mahoning sandstone, which is locally very massive. Though the Mahoning sandstone does not crop out in any place to show its locally massive character, drill holes near Ramseytown have shown it to be as much as 165 feet thick. However, the drill holes also indicate it to have an extremely variable character, many thin beds of sandstone often alternating with shale. For this reason the Mahoning sandstone would have little value. Locally, where large boulders have weathered on the surface, it possibly could be broken up and used for road metal.

LIMESTONE

Several beds of limestone are included in the strata of the Brookville quadrangle. They are all relatively thin and, with the exception of the Vanport limestone, not very persistent. They have no commercial value. The Vanport limestone, however, has been dug at many places by farmers for the purpose of burning lime for their fields. The Upper Freeport limestone has been dug in several places. Though it is unlikely that the limestones of the Brookville quadrangle will ever be commercially valuable, the Vanport limestone is of good quality and may sometime be utilized in a small scale for burning to agricultural lime, for making pulverized lime, or for mine dusting.

VANPORT LIMESTONE

The Vanport limestone is lacking in the northern part of the quadrangle and in Knox and Pine Creek Townships. Its presence in the rest of the quadrangle is shown by the crop line on the areal and mineral resources maps. The thickness of the Vanport ranges from 1 to 10 feet. It averages 5 feet. Thirty-two representative sections presented in figures 19-22 show the thickness of the Vanport limestone at many places in the quadrangle.

The following analyses indicate the good quality of the limestone in the quadrangle and close by:

Analyses of Vanport limestone

	1	2	3	4
$CaCO_3$	93.643	96.428	94.392	96.578
$MgCO_3$	1.816	.908	1.702	.832
Al_2O_3, Fe_2O_3	1.310	.990	1.315	.780
SiO_2	2.040	1.300	1.910	1.280
P	.030	.034	.031	.037

Location of specimens

1. William Hanna property, 2 miles northeast of Sprankle Mills.
2. A. Enty property, half a mile southeast of Worthville.
3. C. Bovaird property, 3 miles northwest of Brockwayville.
4. Samuel Shield property, 1 mile north of Dowlingville.

These analyses are from Pennsylvania Second Geological Survey report M 3.

OTHER LIMESTONES

The most important limestone next to the Vanport is the Upper Freeport. Where it occurs the limestone lies almost immediately under the underclay of the Upper Freeport coal. It is not a persistent member in the Brookville quadrangle. A drill record of the Shawmut Mining Company on the Millen farm in Oliver Township showed 25 feet of limy strata at this horizon. At another place on the Millen farm the limestone proved to be 7 feet thick. A record from the Henderson farm in Oliver Township showed 20 feet of limy strata interbedded with sandstone. Three feet of limestone was reported underneath the Upper Freeport coal in Ringgold Township.

In addition to the erratic physical nature of the Upper Freeport limestone, its chemical character is extremely variable. The following analyses from the quadrangle and other parts of Jefferson County show this:

Analyses of Upper Freeport limestone

	1	2
CaO	43.95	31.56
MgO	2.15	1.33
SiO_2	9.24	24.98
Fe_2O_3	3.93	4.04
Al_2O_3	2.84	8.88
Ignition ..	37.49	27.83

	3	4	4a	5
$CaCO_3$	89.107	48.571	90.00	91.875
$MgCO_3$	1.611	23.762	2.86	2.421
Al_2O_3, Fe_2O_8	2.140	7.250	1.285	1.312
SiO_2	6.170	16.66	3.48	3.13
P	.024	.032	.011	.012

Location of specimens

1. One mile north of Cliff School, Beaver Township.
2. One mile west of Green Valley, Knox Township.
3. One mile southeast from Brockwayville.
4. One mile northwest from Perryville.
5. Two miles northwest from Frostburg.

These specimens are from areas adjoining the Brookville quadrangle. Nos. 4 and 4a come from different parts of the same bed.

The Lower Freeport limestone was reported in drill sections from Knox Township. On the Reitz farm it is 10 feet thick but present only locally. On the Morrison farm it is 2 feet thick. Just west of Summerville 2 feet of limestone crop below a thin bed of Lower Freeport coal.

The Johnstown cement bed was not seen to crop out anywhere in the quadrangle. Several drill holes have shown a 2-foot bed of limestone at a horizon between the Upper and Middle Kittanning coals which is probably this limestone.

Drill holes on the Millen farm in Oliver Township showed about 6 feet of Mahoning limestone and 2 feet of Brush Creek limestone (Fig. 6). These limestones do not crop out anywhere. Further, they are impure and present only locally, so they have little value.

SAND AND GRAVEL

At Summerville Redbank Creek makes two sharp bends. In these bends a flood plain has been built up by the creek. Investigation of this area may reveal some sand and gravel. A similar flood plain extends along Little Sandy Creek from Langville to Cool Spring and East Branch. The area covered by alluvium averages a quarter of a mile in width. Immediately south of Worthville alluvium extends a mile up Big Run. Possibly some of this material may be good sand and gravel.

IRON ORE

The buhrstone iron ore, which consists of concentrations of impure siderite, limonite, and hematite, usually in the form of concretions, lies directly above the Vanport limestone where it is present and in the horizon of the Vanport limestone where it is absent. The metallic content of the ore is about 34 percent. The so-called ore is fairly persistent over the quadrangle. Often it is only 3 or 4 inches thick; it has been observed to be 2 feet thick. In the early part of the 19th century a small furnace at Furnace School, 2 miles west of Corsica, used the buhrstone ore at that place, and the associated Vanport limestone for flux. In the adjoining Smicksburg quadrangle the old Phoenix Furnace at Milton, 3 miles northeast of Dayton, handled ore from a 2- to 4-foot bed of impure hematite which was mined near Milton around 1860. It is doubtful whether the buhrstone ore in the Brookville quadrangle will ever have any economic value. It is probably too thin and impure to be utilized even if the present huge iron ore resources of the United States were drastically curtailed.

WATER RESOURCES*

The mean annual precipitation on the area, as determined from records for Brookville, is 40.22 inches. Records from the precipitation station at Brookville are presented in the chapter on climate from the years 1916 to 1940 inclusive. Incomplete records for a few months during that period prevented the computing of an annual mean for nine of the years. The maximum yearly amount recorded at the station was 51.01 inches in 1937, and the minimum was 30.26 inches in 1930.

The precipitation records for Pennsylvania are published in detail by the United States Weather Bureau in their monthly and annual Climatological Data.

A stream flow gaging station was established on Redbank Creek at St. Charles in 1910 and records are available from 1918 to 1921 and 1931 to 1940. The drainage area at St. Charles is 528 square miles. The mean annual discharge based on 24 years of observation has been 891 second-feet. The maximum discharge was 35,200 second-feet in March 1936. The minimum registered flow was 10 second-feet in August 1910. The gaging station records are published by the United States Geological Survey and the Pennsylvania Department of Forests and Waters.

In general the maximum run-off is during March and April. The winter months of December, January, and February have greater than average run-off records unless the streams are frozen. The summer and fall months are variable and for different years show above average or lower than average run-off records.

Ground water

The ground water is that which permeates the ground. It runs out as springs, is taken up by plants, or is raised from wells for household or other uses. Rain water descends into the ground along fractures or porous portions of rocks until it reaches either an impervious stratum or the level of saturation or water table. The impervious strata encountered in this area are most commonly the beds of clay that underlie coal beds. Reaching such a layer, the water may follow it down the dip to its outcrop, where the water escapes as springs. If, on the other hand, it first reaches the water table, it tends temporarily to raise the level of that table, causing increased outflow in the valleys where the water table reaches the surface. The underground waters move in the same direction as the surface waters. In a general way, the water table follows the topography of the surface, though it is less rugged in shape. As a rule, it is near the surface in the valleys, and is farthest from the surface on the hills. The depth of the water table varies with the character of the surface, the character of the underlying rock, and the season. It will be nearer the surface in broad flat areas than near sharp declivities where the water may drain away readily. It will be nearer the surface underlain by fine-grained rocks, such as shales, than one underlain by coarse-grained rocks like sandstone. The water table rises rapidly after heavy rains and then gradually sinks again as the water drains away. During rainy weather and for a time afterwards the streams carry more or less water that has flowed down the surface without entering the ground. During the drier seasons, practically all the stream run-off is derived from underground circulation.

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* For further details, see Leggette, R. M., Ground water in northwestern Pennsylvania: Pennsylvania Topog. and Geol. Survey, Bull. W3, 1936.

The Brookville quadrangle is fairly supplied with ground water. Small springs are common. The sandstones of the Conemaugh, Allegheny, and Pottsville formations are all good water horizons locally. In some areas their yield is small.

As in many parts of northwestern Pennsylvania, water of the Brookville quadrangle is frequently high in iron. Generally, the water is soft. As may be seen from the following analyses of some waters from the quadrangle, the sodium chloride and total solid content is high.

Analyses of waters in the Brookville quadrangle

(Parts per million. Numbers refer to Bull. W3)

No.	Depth of well, feet	Total dissolved solids	SiO_2	Fe	Ca	Mg	Na, K	HCO_3	SO_4	Cl	NO_3	Total hardness $CaCO_3$	Temp. °F
476	280	1155	8.5	1.69	49	12	380	197	8.1	593	1.9	172	----
477	212	1582	---	2.71	72	--	548	167	1.5	900	.20	217	----
1017	---	423	---	----	74	--	52	147	208	1.5	5.1	230	50

Nos. 476 and 477 represent water samples from wells in the Pottsville formation half a mile east of Summerville. No. 1017 is from a spring half a mile east of Summerville.

Domestic supplies

In the rural areas and the villages both dug and drilled wells are used. However, dug wells have proved unreliable at many places and are being replaced by drilled wells. The dug wells range between 10 and 30 feet in depth. The drilled wells have a wide range of depth. Some are nearly 300 feet deep.

In addition much of the domestic water supply is obtained from springs. Some of these springs issue from the coal horizons and may contain a high percentage of "sulphur" derived from the coal.

Public supplies

Brookville takes its water supply from North Fork and is the only town in the quadrangle that uses surface water. The storage system holds 2 million gallons.

The Allegheny River Mining Company supplies water to Conifer by two drilled wells. The water does not require further treatment. There are facilities for storing 20,000 gallons.

Summerville is supplied through the Peoples Water Company by two springs from joints in the Vanport limestone and two drilled wells in the Pottsville formation. The water is lifted by deep-well pumps and there is a 100,000 gallon storage system. The waters are untreated. Daily average consumption is 60,000 gallons.

The villages have no public system and are supplied mainly by drilled wells and springs.

Artesian conditions

The structure of the formations in the Brookville quadrangle is such that in many places wells encounter water under artesian pressure. In most places this pressure is not sufficient to make the water flow at the surface, but it is not uncommon to encounter water that rises 10 to 20 feet above the level at which it was encountered. These artesian wells are located between the anticlinal axes. Wells close to the synclinal axes generally have water under the greatest artesian pressure. For this reason, flowing wells are more likely to be obtained in these regions.

Water power, storage and flood control

At the present time this area presents little inducement for water-power projects of any size. Present interest will probably be in the possible utilization of some of the small streams of the region in the production of small quantities of power for local domestic use. In some sections of the country small streams are being used for lighting individual houses or groups of houses and for running machines on the farm and in the house. In some parts of this area the streams rise on the upland and flow one or two miles before descending sharply to the main valley. Such streams have a very small flow at most times and may be dry during draught, but, as the fall may amount to 100 or 200 feet in half a mile, it would seem that such streams could be utilized in a small way.

In a region situated as this is, in the heart of the coal field, with cheap coal everywhere available, water power cannot compete with the coal because of the large cost of installation except where the conditions for such installation are very exceptional. There are practically no waterfalls in the area, but low cascades occur where streams descend from the upland. To take advantage of such conditions involves always the building and maintenance of a long flume and of a penstock which, in most instances, is expensive to build.

Besides the many possible small developments, a few larger developments may be feasible in the future. As most, if not all, of these projects involve dams of considerable length, usually at least 1,000 feet long on top (for a height of 60 to 100 feet) which would yield only a very limited amount of power, the largest present interest in such places must be as possible sites for impounding dams for water storage for the benefit of stream regulation, larger power plants farther down the rivers, or for flood prevention. Among places of special interest in this line are: The gorge at Redbank Creek in the southwestern part of the quadrangle, and the deep valley of North Fork north of Brookville. These two places have not been examined in the field with this thought specifically in mind.

APPENDIX A

COAL RESERVES

The following table shows the approximate area (in square miles) of each township, or part of township, that lies within the boundary of the Brookville quadrangle. Under each township the principal coal beds are named, with their average thickness and tonnage data on the amount of the original deposit, the amount mined out and lost, and the amount recoverable.

Most of the figures presented here are the results of the work of Mr. James D. Sisler as presented in the Survey Bulletin M6, on the Coal Resources of the Bituminous Coal Fields. The data were gathered between 1925 and 1930. Because the area of the Brookville quadrangle has never been one of much mining, the essential value of the figures has not changed a great deal in the last 15 years. This is especially true in view of the fact that coal mining has suffered a steady and increasing decline since the boom years following World War 1. It is important to keep in mind that these figures are approximate and represent the best conclusion possible from all the data as interpreted by one person. Another person may arrive at different results. It is safe to say, however, that the figures do show the relative importance of the coal beds and their value as reserves.

No figures are presented for the Mercer coal, mainly because the data are insufficient. Likewise, the Clarion coal is considered only in those townships in Clarion County because not enough was known about it in the other townships to present estimates of reserves. It is intended that this table be used as an aid, along with the description of each of the coal beds in the chapter on Mineral Resources, to obtain a true picture of the coal beds in the Brookville quadrangle.

Coal resources in Brookville quadrangle

Jefferson County

Bed	Workable area (sq. mi.)	Original deposit	Mined out and lost	Recoverable	Percent recoverable	Avge. thickness (inches)
Union Township Area 18.4 sq. mi.						
Brookville	12	27,900,000	1,000,000	17,500,000	65	24
L. Kittanning	8	23,300,000	500,000	16,000,000	70	30
M. Kittanning	5	14,500,000	--------	11,000,000	70	30
U. Kittanning	3	8,700,000	--------	6,000,000	70	30
Total	28	74,400,000	1,500,000	50,500,000	--	--
Clover Township Area 17.00 sq. mi.						
Brookville	10	46,600,000	5,000,000	30,800,000	75	48
L. Kittanning	2	5,800,000	500,000	3,700,000	70	30
M. Kittanning	1	2,900,000	--------	2,000,000	70	30
Total	13	55,300,000	5,500,000	36,500,000	--	--

Jefferson County—Continued

Bed	Workable area (sq. mi.)	Original deposit	Mined out and lost	Recoverable	Percent recoverable	Avge. thickness (inches)
Beaver Township Area 21.76 sq. mi.						
Brookville	14	65,200,000	8,000,000	40,000,000	70	48
L. Kittanning	2	5,800,000	500,000	3,700,000	70	30
Total	16	71,000,000	8,500,000	43,700,000	—	—
Rose Township including Brookville Borough Area 21.24 sq. mi.						
Brookville	12	34,900,000	1,000,000	23,700,000	70	30
L. Kittanning	3	7,000,000	500,000	4,200,000	65	24
M. Kittanning	1	3,500,000	700,000	2,000,000	70	36
Total	16	45,400,000	2,200,000	29,900,000	--	--
Ringgold Township Area 11 sq. mi.						
L. Kittanning	8.8	25,630,000	2,750,000	14,850,000	65	30
M. Kittanning	7.2	16,665,000	--------	10,835,000	65	24
U. Kittanning	5.5	12,815,000	--------	8,305,000	65	24
L. Freeport	4.4	15,400,000	110,000	10,725,000	70	36
U. Freeport	3.3	9,625,000	3,850,000	4,070,000	70	30
Total	29.2	80,135,000	6,710,000	48,785,000	--	--
Oliver Township Area 22.55 sq. mi.						
Brookville	20.0	46,000,000	743,000	29,600,000	65	24
L. Kittanning	11.0	25,600,000	121,000	17,800,000	70	24
M. Kittanning	4.0	9,300,000	200,000	5,920,000	65	24
L. Freeport	2.0	11,600,000	500,000	9,400,000	85	60
U. Freeport	1.0	5,800,000	500,000	4,940,000	85	60
Total	38	98,300,000	2,064,000	77,660,000	--	--
McCalmont Twp. Area 3.25 sq. mi.						
L. Kittanning	3	7,550,000	--------	4,760,000	65	24
M. Kittanning	2.5	5,810,000	--------	3,900,000	65	24
L. Freeport	1.5	8,710,000	1,610,000	5,700,000	70	60
U. Freeport	1.0	3,120,000	858,000	1,590,000	50	30
Total	8.0	25,190,000	2,468,000	11,190,000	--	--
Knox Township Area 26 sq. mi.						
Brookville	17	59,200,000	1,700,000	37,500,000	65	36
L. Kittanning	13	22,700,000	244,000	13,450,000	60	18
M. Kittanning	9	21,000,000	750,000	12,200,000	60	24
U. Freeport	4	23,300,000	665,000	18,180,000	80	60
Total	43	126,200,000	3,359,000	81,330,000	--	--
Pine Creek Twp. Area 14 sq. mi.						
Brookville	5	29,000,000	417,000	18,500,000	65	36
L. Kittanning	2	4,640,000	--------	3,000,000	65	24
Total	7	33,640,000	417,000	21,500,000	--	--

Jefferson County—Concluded

Bed	Workable area (sq. mi.)	Original deposit	Mined out and lost	Recoverable	Percent recoverable	Avge. thickness (inches)
Warsaw Township Area 14 sq. mi.						
Brookville	5.5	19,210,000	30,000	1,000,000	5	36
Eldred Township Area 22 sq. mi.						
Brookville	6	18,000,000	120,000	2,000,000	10	32
Clarion County						
Mill Creek Twp. Area 6 sq. mi.						
Brookville	2.5	4,380,000	--------	2,630,000	60	18
Clarion township Area 4.5 sq. mi.						
Brookville	3	5,840,000	--------	3,800,000	65	20
Clarion	2.5	8,200,000	680,000	5,700,000	70	36
L. Kittanning	1	3,280,000	100,000	2,000,000	65	36
Total	6.5	17,320,000	780,000	11,500,000	--	--
Limestone Twp. Area 10 sq. mi.						
Brookville	3	5,230,000	500,000	3,140,000	65	18
Clarion	3	9,300,000	1,500,000	5,060,000	65	32
L. Kittanning	2.5	8,720,000	320,000	5,480,000	65	36
U. Freeport	1	3,700,000	--------	2,200,000	60	38
Total	9.5	26,950,000	2,320,000	15,880,000	--	--
Redbank Township Area 9 sq. mi.						
L. Kittanning	4	14,000,000	630,000	9,300,000	70	36
U. Freeport	.75	2,780,000	115,000	1,600,000	60	38
Total	4.75	16,780,000	745,000	10,900,000	--	--
Armstrong County						
Redbank Township Area 6 sq. mi.						
L. Kittanning	2	5,820,000	40,000	3,900,000	65	32
U. Freeport	0.2	760,000	20,000	565,000	80	44
Total	2.2	6,580,000	60,000	4,465,000	--	--

APPENDIX B

LIST OF COAL MINES

The following list of coal mines includes mainly those mines and country banks that are located by number on the mineral resources map and of which sections appear in the chapters on Stratigraphy and Mineral Resources. It is not a complete list of mines in the Brookville quadrangle. It is probable that some of the mines listed are known by other names but, wherever possible, the most recent name was obtained and so appears on the list. Most of these mines are abandoned; some have not operated for more than 20 years. However, these are included in the list because they were important in the preparation of the report.

Map	Name of mines	Coal bed	
Ab1	Caved coal bank	C	M. Kittanning
Ab2	Pawnee	B	L. do
Ab3	DeHaven stripping	B	do
Ab4	Flemming	A′	Clarion
Ac1	Reed country bank	E	U. Freeport
Ac2	Reed	B	L. Kittanning
Ac3	Pennsy No. 7	B	do
Ac4	Sutton No. 10	B	do
Ac5	Williams	B	do
Ac6	Sutton No. 9	A	Brookville
Ac7	Elba stripping	B	L. Kittanning
Ac8	Carrier stripping	B	do
Ac9	Fairman	A′	Clarion
Ac10	Oak Valley No. 1	A′	do
Ac11	Cummings	A	Brookville
Ad1	Country bank	E	U. Freeport
Ad2	Brosius Bank	E	do
Ad3	Yaney bank	E	do
Ad4	Country bank	E	do
Ad5	Country bank	E	do
Ad6	Country bank	B	L. Kittanning
Ad7	Blotzer bank	B	do
Af1	Country bank	E	U. Freeport
Af2	Country bank	E	do
Af3	Clyde Shick bank	B	L. Kittanning
Bb1	Pawnee	B	do
Bb2	DeHaven Coal Co.	B	do
Bb3	Sells coal bank	B	do
Bb4	George Winters bank	B	do
Bc1	Pennsy No. 5	B	do
Bc2	Hanley No. 3 (clay)	B	do
Bc3	Country bank	B	do
Bc4	Coleman Clay Co. (clay)	B	do
Bc5	Country bank	A′	Clarion
Bc6	Country bank	A′	do
Bc7	Viaduct	A	Brookville
Bd1	Country bank	B	L. Kittanning
Bd2	Pennsy No. 6	B	do
Bd3	Stahlman coal bank	B	do
Bd4	Pennsy No. 10	A	Brookville
Bf1	Snyder bank	B	L. Kittanning
Bf2	Country bank	B	do
Cb1	Country bank	C	M. do
Cb2	Small coal stripping	B	L. do
Cb3	Triangle Coal Co.	B	do
Cb4	Cowan coal bank	B	do
Cb5	Country bank	B	do
Cb6	Corbin bank No. 2	B	do
Cb7	Summerville bank	B	do
Cb8	Corbin No. 1	A	Brookville
Cc1	Country bank	B	L. Kittanning
Cc2	Country bank	B	do
Cc3	Country bank	B	do
Cc4	McCullough No. 3	A	Brookville
Cc5	Glen	A′	Clarion
Cd1	Leslie Shield bank	B	L. Kittanning
Cd2	Coal bank	B	do
Cd3	Conifer No. 5	A	Brookville
Cd4	Conifer No. 6	A	do
Ce1	Country bank, Pifer & Kuntz	E	U. Freeport
Ce2	Country bank, D. E. Reitz	E	do
Ce4	Country bank	B	L. Kittanning
Ce5	Country bank	B	do
Ce6	Norman Geist bank	B	do
Ce7	Conifer No. 3	A	Brookville
Ce8	Conifer No. 4	A	do
Ce9	Conifer No. 1	A	do

Map	Name of mines	Coal bed	
Ce10	Conifer No. 2	A	do
Cf1	Coal prospect	E	U. Freeport
Cf2	Country bank, Martz	E	do
Cf3	John Stormer bank	B	L. Kittanning
Cf4	Blake Geist bank	B	do
Cf5	Country bank	B	do
Db1	Country bank	B	do
Db2	Mineweaser	A	Brookville
Dc1	R. A. Beckman bank	B	L. Kittanning
Dc2	Country bank	B	do
Dc3	Caved coal bank	A	Brookville
Dc4	Caved bank	A′	Clarion
Dd1	Stanton No. 2	C	M. Kittanning
Dd3	Thrush country bank	B	L. do
Dd4	Coal crop	B	do
Dd5	Renninger bank	B	do
Dd6	Yates	A	Brookville
Dd7	Hunt's Run	A	do
Dd8	Campbell	A	do
Dd9	Pawnee	A	do
De1	Renninger country bank	E	U. Freeport
De2	Ramsey No. 5	E	do
De3	Country bank	E	do
De4	Country bank, Hamil	E	do
De5	Country bank, Felicetti	E	do
De6	Country bank, Galbraith	E	do
De7	Country bank, Himes	E	do
De8	Country bank	E	do
De9	Anita Coal Co., Helena	E	do
De10	Country bank, Taney	E	do
De11	Country bank	E	do
De12	McGarey No. 1, formerly Cherokee	C	M. Kittanning
De13	McGarey No. 2	B	L. do
De14	C. F. Hoffman coal bank	B	do
Df1	Country bank	B	do
Df2	Country bank	D	L. Freeport
Df3	Hawthorne bank	B	L. Kittanning
Df4	Country bank	B	do
Ed1	Yates country bank	E	U. Freeport
Ed2	Stewart No. 1	E	do
Ed3	Country bank	E	do
Ed4	Country bank	E	do
Ed5	Ramsay B	E	do
Ed6	Hilltop	B	L. Kittanning
Ed7	Meadow Brook No. 1	A	Brookville
Ee1	Ramsay No. 2	E	U. Freeport
Ee2	Ramsay No. 1	E	do
Ee3	Ramsay No. 3	E	do
Ee4	Ramsay No. 6	E	do
Ee5	Country bank	E	do
Ee6	Ramsay No. 4	E	do
Ee7	Country bank, Geers farm	E	do
Ee8	Country bank		Brush Creek
Ee14	Country bank	C	M. Kittanning
Ee15	Peterson coal bank	B	L. do
Ee16	East Branch No. 5	B	do
Ef1	East Branch No. 1	C	M. Kittanning
Ef2	Country coal bank	B	L. do
Ef3	East Branch No. 2	B	do
Ef4	Country coal bank	B	do
Ef5	Oliver	B	do
Ef6	Kougher coal bank	B	do
Ef7	Machob coal bank	B	do
Fd1	Stewart No. 3	E	U. Freeport
Fd2	Stewart No. 2	E	do
Fd3	Wolfe Ridge	E	do
Fd4	Country bank	C	M. Kittanning
Fd5	Country bank	C	do
Fe1	R. R. cut, P. & S. coal crop	E	U. Freeport
Fe2	Country bank, Tates	E	do
Fe3	Shetland No. 1	C	M. Kittanning
Fe4	Campbell No. 2	C	do
Fe5	Green Valley No. 1 or Henderson	C	do
Fe6	Probably Colonial	C	do
Fe7	Abandoned mine	C	do
Fe8	Shetland No. 2	B	L. Kittanning
Fe9	Stewart No. 7	E	U. Freeport
Fe10	Campbell No. 1	E	do
Ff1	Parker Nichols bank	D	L. Freeport
Ff2	Parker Nichols bank	D	do
Ff3	Lucy Means bank	B	L. Kittanning

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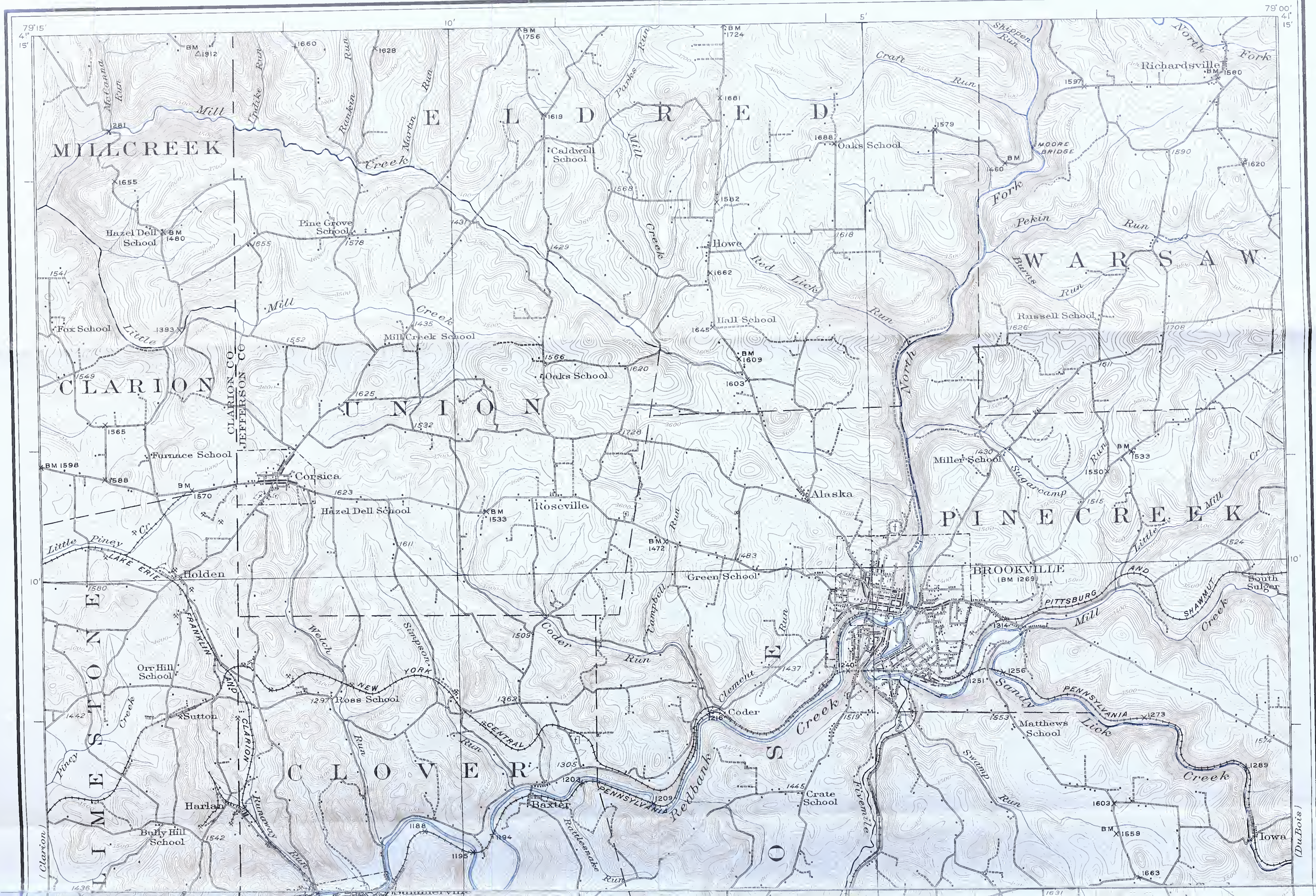

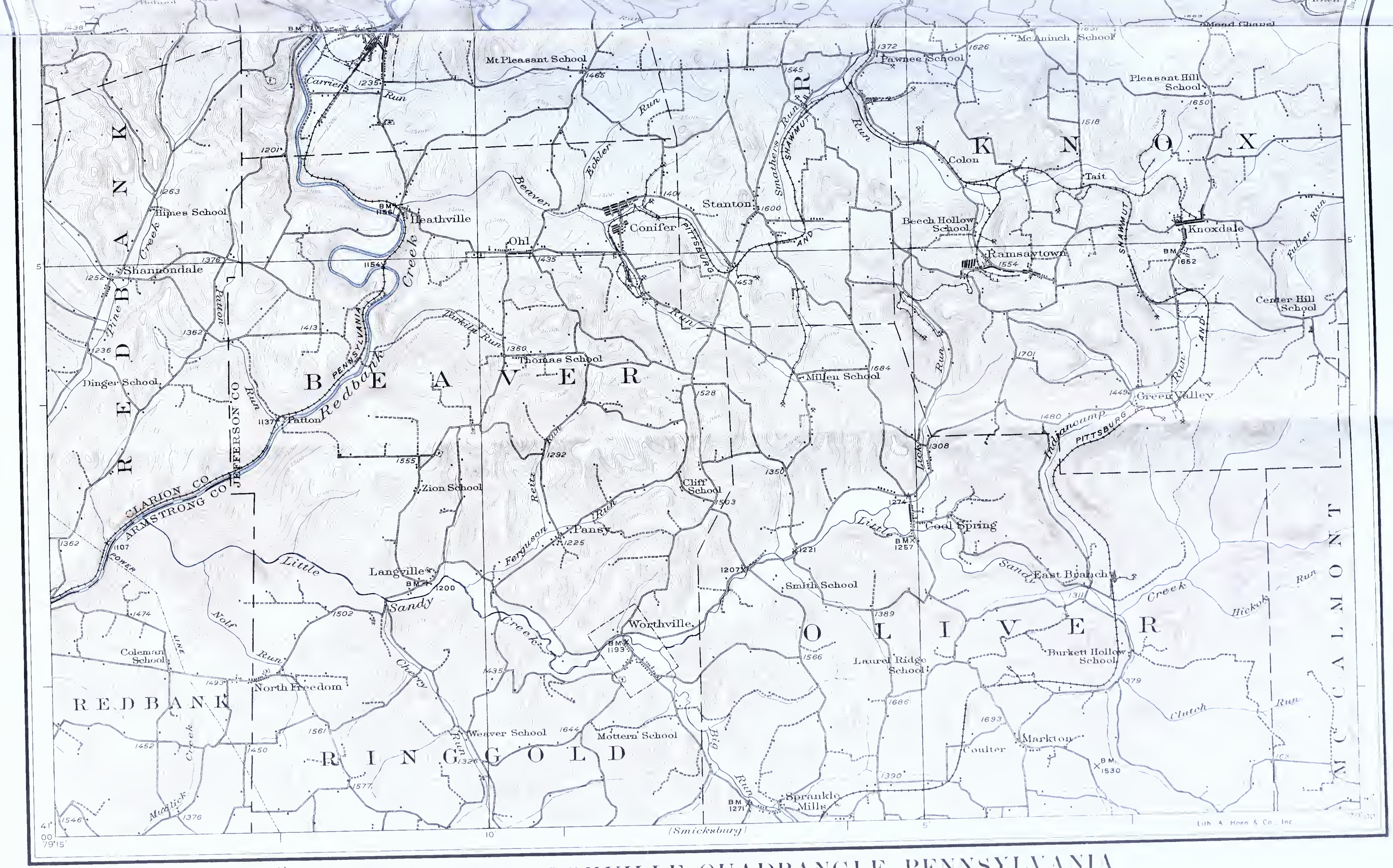

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MAP OF THE BROOKVILLE QUADRANGLE, PENNSYLVANIA

Showing Topography

Scale $\frac{1}{62500}$

1 0 1 2 3 4 Miles

5000 0 5000 10000 15000 20000 Feet

1 0 1 2 3 4 5 Kilometers

Contour interval 20 feet

Datum is mean sea level

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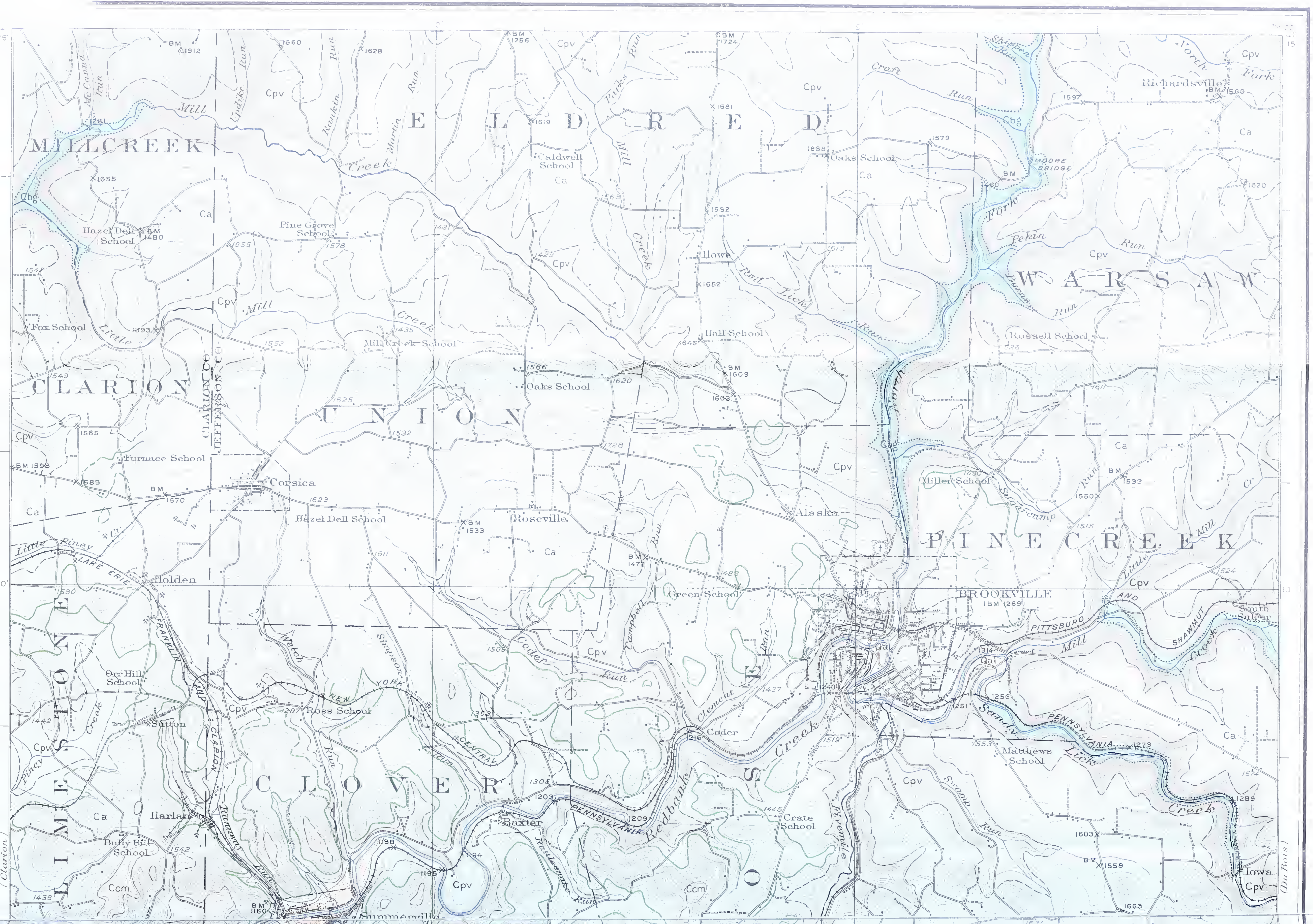


EXPLANATION

SEDIMENTARY ROCKS

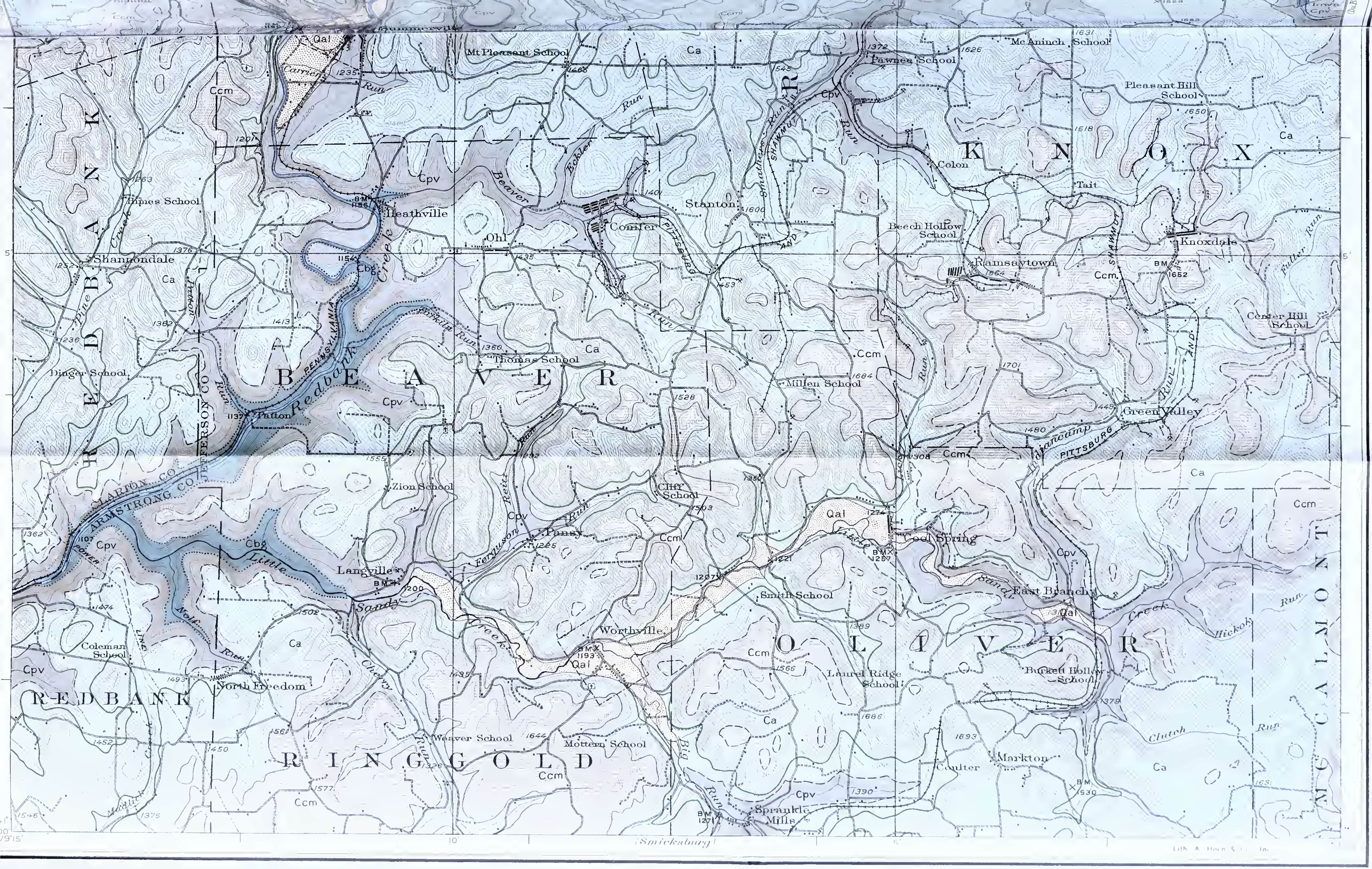
Qal
Alluvium
(in flood plains of present streams)

Ccm
Conemaugh group
(shale, thin limestone, sandstone, some red shale, thin coal beds, and coarse thick-bedded sandstone comprising Mahoning member)

Ca
Allegheny group
(chiefly light and dark gray shale with variable beds of coarse gray sandstone and several valuable coal beds. Upper Freeport coal on top, Brookville coal at base, containing Clarion and other sandstone members and the Vanport limestone, v)

Cpv
Pottsville series
(thick-bedded sandstone with shale in middle locally carrying the Mercer coals and clay)

Cbg
Pocono series
(tan and white medium grained, massive Burgoon sandstone)



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Showing Areal Geology

Geology by C. K. Graeber.

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles
5000 0 5000 10000 15000 20000 Feet
1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 20 feet

Datum is mean sea level

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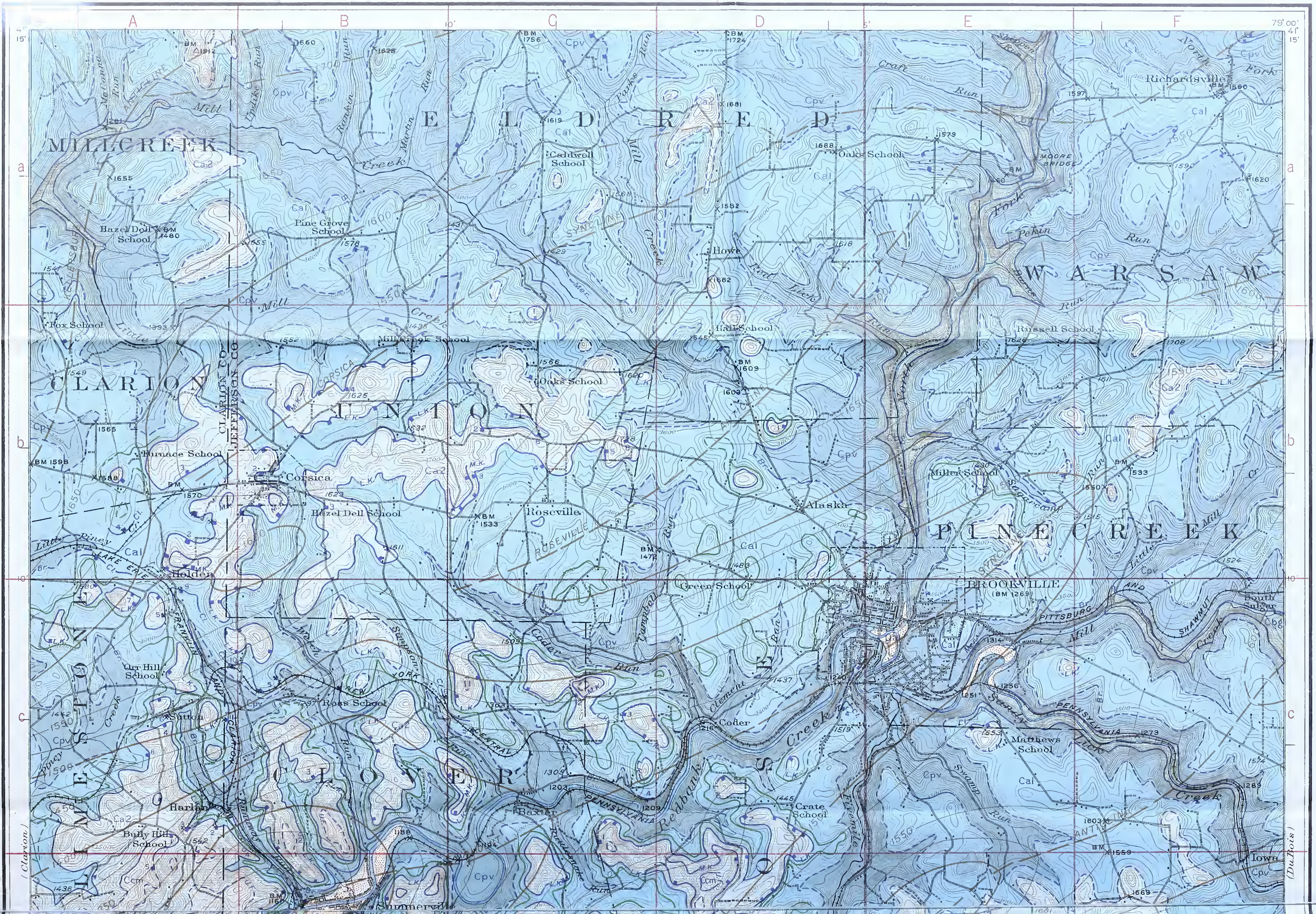


EXPLANATION

Qal	Alluvium *(in flood plains and valley bottoms)*
Ccm	Conemaugh group *(area of outcrop of the rocks above the Upper Freeport coal)*
Ca2	Allegheny group *(rocks between the base of the Upper Freeport coal and the base of the Lower Kittanning coal)*
Cal v	Allegheny group *(rocks between the bases of the Lower Kittanning and the Brookville coals with the Vanport limestone, v)*
Cpv	Pottsville series *(rocks between the top of the Homewood sandstone and the base of the Connoquenessing sandstone, including the Mercer coal and clay)*
Cbg	Pocono series *(Burgoon sandstone)*

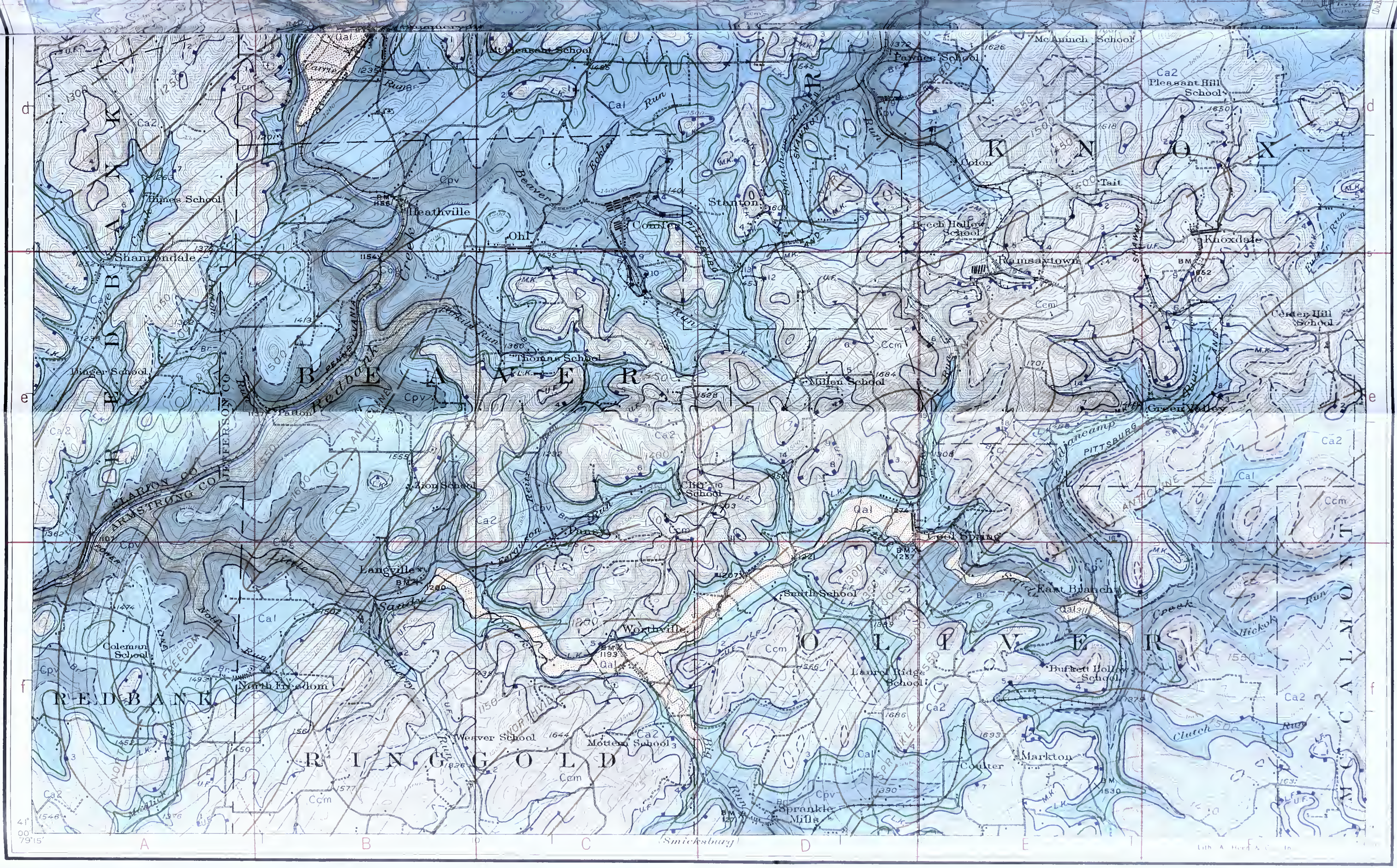
COAL AND CLAY

Br.Cr.	Brush Creek coal
U.F.	Upper Freeport coal
L.F.	Lower Freeport coal
U.K.	Upper Kittanning coa
M.K.	Middle Kittaning coal
L.K.	Lower Kittanning coa
Cl.	Clarion coal
Br.	Brookville coal
Mer.	Mercer coal

SYMBOLS

— Coal mine
— Coal outcrop
— Clay mine
— Clay outcrop

Structure contours on
Vanport limestone
Contour interval 25 feet
Datum is mean sea level



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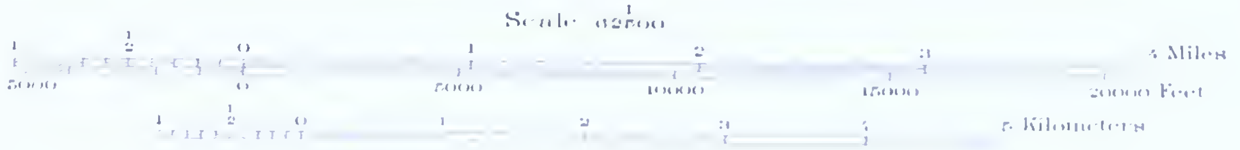
MAP OF THE BROOKVILLE QUADRANGLE, PENNSYLVANIA

Showing Mineral Resources

Geology and mineral resources by
C. K. Graeber.

Scale $\frac{1}{62500}$



Contour interval 20 feet
Datum is mean sea level

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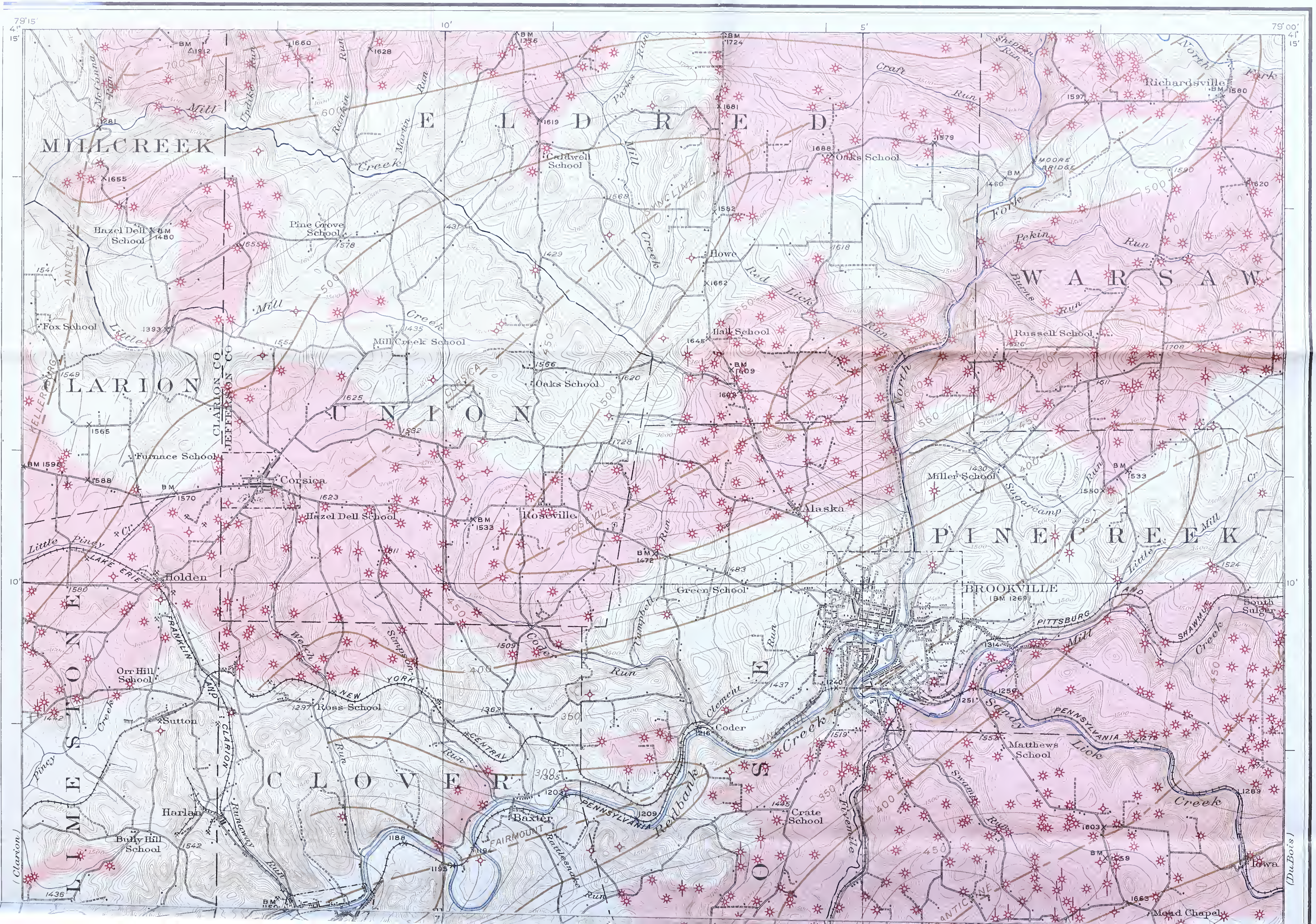


EXPLANATION

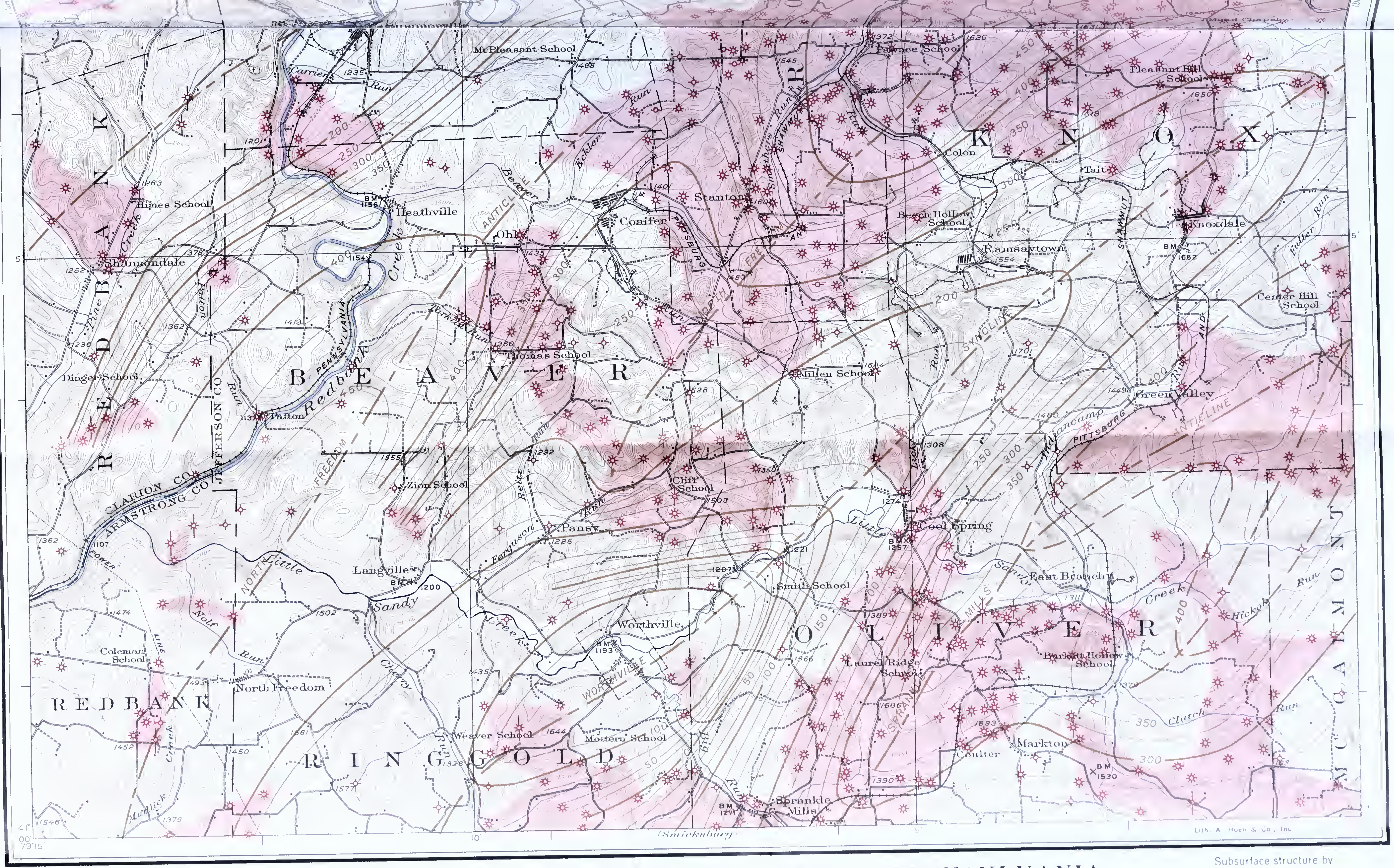
▨ Gas pools

Structure contours on top of red rock (*Catskill formation*)
Contour interval 25 feet
Datum is mean sea level

✳ Gas well

✳ Abandoned gas well

✧ Dry hole



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MAP OF THE BROOKVILLE QUADRANGLE, PENNSYLVANIA

Showing Subsurface Structure and Gas Areas

Subsurface structure by
C. K. Graeber, H. H. Hughes,
and M. N. Shaffner.

Scale $\frac{1}{62500}$

Contour interval 20 feet

Datum is mean sea level

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